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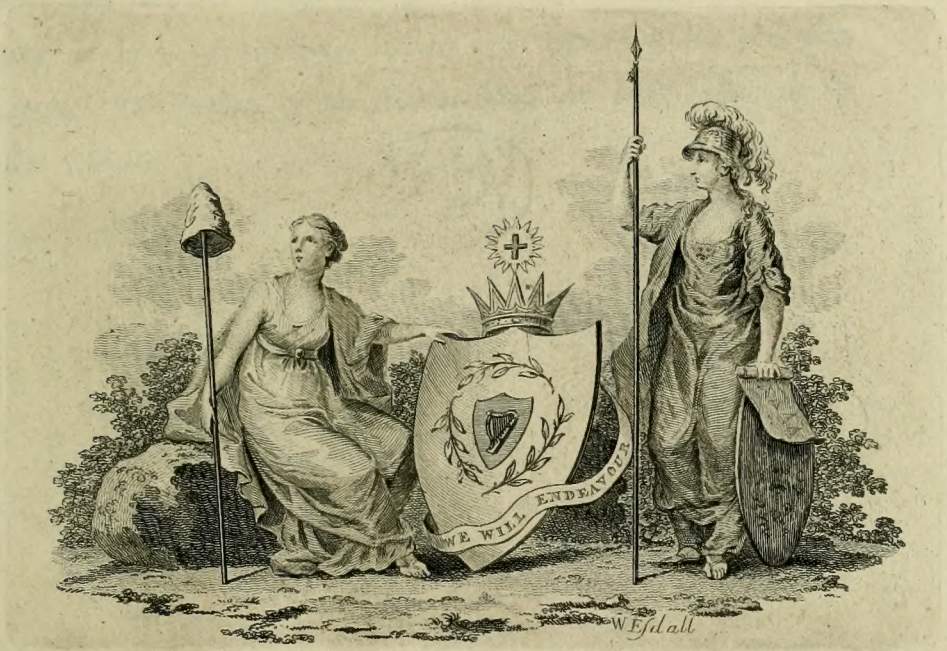
THE

TRANSACTIONS

OF THE

ROYAL IRISH ACADEMY.

VOL. VI.



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THE TRANSACTIONS OF THE ROYAL IRISH ACADEMY.

VOL. VI.

THE ACADEMY desire it to be underſtood, that, as a body, they are not anſwerable for any opinion, repreſentation of facts, or train of reaſoning, which may appear in the following papers. The authors of the ſeveral eſſays are alone reſponſible for their contents,

ERRATA.

Science.

Page 52, Line 15, *for* ſeem, *read* ſeems.
Page 53, Line 11, *for* theſe, *read* thoſe.
Page 58, Line 18, *for* complaints, *read* complains.
Page 63, Line 5, *for* there, *read* their.
Page 147, Line 6, *for* lighter, *read* greater.
Page 179, Line 13, *for* did not only, *read* did not not only.
Page 183, Line 14, *for* and the direct or, *read* either directly, or in the.
Page 201, Line 3, *for* L', *read* L.
Page 203, Line 12, *for* for, *read* from.
Page 206, Line 17, *for* 12, *read* 12 H.
Page 225, Line 22, *for* plus, *read* minus.
Page 226, Line 16, *for* $\sqrt{a^2 - ay}$, *read* $\sqrt{a^2 - ay}$.
Page 273, Line 11, *for* degrees, *read* ſeconds.
Page 297, Line 13, *for* collocts, *read* collects.
Page 306, Line 8, *for* be, *read* been.
Page 307, Line 12, *for* Lava, *read* Lavas.
Page 321, Line 2, *for* 1785, *read* 1795.
Page 344, Note, Line 6, *dele* to.
Page 365, Line 7, *for* moſt and ſooneſt, *read* more and ſooner.

Polite Literature.

Page 14, Line 15, *for* in Fables, *read* in the Fables.
Page 16, Line the 3d from the bottom, *for* Eumieus, *read* Eumæus.
Page 29, Line 12, *for* prediſpoſes, *read* prediſpoſe.
Page 33, Line 16, *for* it, *read* they.
Page 63, Line 3, *for* then, *read* thus.
———, Line 7, *for* 1788, *read* 1688.
Page 48, Line 5, *for* corponding, *read* correſponding.

Antiquities.

Page 15, Line 19, *for* Duke of Bedford, *read* the Duke of Bedford.

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SCIENCE.

REMARKS *on the* CAUSES *and* CURE *of ſome* DISEASES *of* INFANCY.

By JOSEPH CLARKE, *M. D. Licentiate in Phyſic of the Royal College of Phyſicians in Dublin, and M. R. I. A.*

Read July 6, 1793.

IT is now near ſeven years ſince an eſſay of mine was read before this Academy, on the properties of human milk, the changes it undergoes in digeſtion, and the diſeaſes ſuppoſed to originate from this ſource in infancy. A variety of facts and obſervations was then brought forward to render it probable that the cauſes, commonly alleged by writers to produce moſt of the diſeaſes of infants, are ill founded, nay, do not exiſt; and conſequently that the remedies propoſed for their cure moſt often prove ineffectual. Since the above period my attention has been very much directed to this ſubject, and it is well known that my opportunities of experience have not been inconſiderable; and yet I every day feel more forcibly the evidence in favour of my former doubts. Once more, therefore, I am tempted to ſolicit attention to

this ſubject, by ſubmitting the following remarks, however curſory and imperfect, to public conſideration: They relate principally to four diſeaſes, viz.

I. Diarrhœa, accompanied with much griping and green ſtools.

II. Obſtinate coſtiveneſs.

III. Nine day fits, or convulſions in early infancy.

IV. Cutaneous eruptions.

As it can be of no uſe to repeat what preceding writers have ſaid on theſe ſubjects, I ſhall confine myſelf to ſuch remarks as are not commonly to be met with in print.

In the eſſay above mentioned * I endeavoured to prove that green ſtools in infancy are not to be conſidered as ſure ſigns of the exiſtence of a ſuperabundant acid in the ſtomach and inteſtines; at that time I was totally ignorant of their nature. An accident firſt ſuggeſted to me new ideas on this ſubject. A lady of very acute talents took it into her head that the milk of a nurſe in her ſervice did not agree with her infant. One night this infant, after ſuffering a great deal of griping, paſſed a remarkably green ſtool, which the mother conſidered as

* See Tranſactions of the Royal Iriſh Academy for the year 1788.

as a deciſive proof that nurſe's milk turned ſour in her child's ſtomach, and of courſe muſt diſagree with it. The cloth on which this ſtool was received happened to be thrown into a corner of the room, where it lay 'till next morning, when nurſe, to her great ſurprize, found it had changed the *green* for a *natural yellow* colour. The miſtreſs ſuſpected miſrepreſentation on the part of the nurſe, and I was ſent for to decide between them. Not knowing well how to give a ſatisfactory determination, I begged of the lady to ſuſpend her judgment, and to remark particularly whether in future ſuch changes, as nurſe deſcribed, would happen. She made the experiment repeatedly with great care, and uniformly found that the green colour changed to a yellow by time, and perhaps by being diffuſed on the cloth. A very particular attention to this caſe led me ſtrongly to ſuſpect that green ſtools in infancy (which medical writers have long imputed to predominant acidity) are often *really* of a *bilious* nature. The inefficacy of abſorbent medicines to correct them, joined to ſome other conſiderations to be hereafter noticed, ſerved ſtill farther to confirm my ſuſpicions. Impreſſed ſtrongly with theſe ideas, I determined to deviate from common practice, by having recourſe to the uſe of calomel, one of the few remedies which experience has found powerfully to influence the biliary ſecretion in adults. It anſwered my expectations ſo well then, and in many ſimilar inſtances ſince, that I am perſuaded it may be of ſome utility briefly to ſtate the reſult of my obſervations reſpecting it.

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As very green ſtools are generally preceded by and accompanied with a great deal of griping and diſtreſs to the infant, they ſeem to me to indicate unuſual acrimony in the bile, and probably ſome degree of depraved ſecretion in the liver. Sometimes this morbid tendency is of ſhort duration, ſometimes it continues troubleſome for weeks. In the former caſes, caſtor oil in moderate quantity will be found a good remedy; it evacuates ſpeedily the contents of the bowels, and at the ſame time ſheaths the inſide of the inteſtinal canal againſt their acrimony. In the more obſtinate caſes, where oil only affords temporary relief, calomel is the only remedy I have found to produce permanent good effects. I am inclined to think it operates not merely by evacuating, but by correcting that tendency to depraved ſecretion which in bad caſes probably exiſts. To infants under ſix months old I generally begin with half-grain doſes, given at bed time, rubbed into a powder, with a little white ſugar. If this quantity do not procure two or three motions in the courſe of the following day, the doſe may be increaſed to three-quarters of a grain, or even a grain. It may be repeated in this manner every night, or every ſecond night, according to the degree of diſtreſs and ſtrength of the patient, until the ſtools aſſume a natural appearance. This they ſeldom fail to do in a week or two, and then all griping and uneaſineſs ceaſe. It will rarely be neceſſary to give more than from four to eight grains of calomel on ſuch occaſions, and I can with the utmoſt confidence aſſert that I have never known it to do any miſchief, and very ſeldom to fail of producing the deſired effects. Nor is it any objection

objection to the uſe of this medicine, that the patient labours under ſome degree of diarrhœa; the acrimony of the ſtools not unfrequently excites frequent and ineffectual efforts, which are to be removed only by a removal of the exciting cauſe. If abſorbents poſſeſs any power in ſuch caſes, they owe it to their combination either with laxatives, eſſential oils, or diſtilled waters; and even with theſe aids I have commonly found them to afford but temporary eaſe.

That infants ſhould be particularly liable to diſorder in the biliary ſecretion can hardly appear ſurpriſing, when it is conſidered that in them the liver bears a much larger proportion to the weight of the body than in adults: This increaſed ſize of the liver, like that of the heart, probably diminiſhes gradually as the body advances towards maturity. The effects of this peculiarity, of ſtructure of infants, are ſtrongly manifeſted in moſt caſes even after birth: although it be a common practice to keep their bowels diſcharging freely, and though their ſtools be evidently loaded with bile, yet during the firſt week few infants eſcape ſome degree of jaundice (commonly called Yellow Gum). Theſe facts prove a very copious ſecretion and excretion of bile at an early period, when the uncommon ſize of the liver is indiſputable; it appears to me probable that the ſame tendency to copious ſecretion muſt continue, in ſome degree, through infancy and childhood until this viſcus be reduced to its ordinary ſize. Medical practitioners have long remarked that well-prepared calomel agrees ſingularly well with the conſtitution of children

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in all thoſe diſeaſes wherein they have thought it prudent to employ it. Do not the peculiarities of ſtructure above noticed afford ſome explanation of this fact? The power of calomel in correcting green ſtools, and the uneaſineſs accompanying them, is a fact which I hope will be admitted by all practitioners who give it a fair trial.

Since the above remarks were written I have met with two or three caſes of violent bilious vomitings and cholics in infants, which were effectually relieved by much greater quantities of calomel than what I have ſtated above. To what extent it may be puſhed in very bad caſes my experience does not yet enable me to determine.

Of obſtinate Coſtiveneſs.

Every one, acquainted with the conſtitution of infants, knows that it is natural to them to have three or four ſtools every twenty-four hours; and that without ſuch diſcharges they ſeldom enjoy perfect health. A few inſtances occur in practice where the inteſtines of infants never diſcharge their contents unleſs irritated by ſome kind of phyſic. I have met with a good many ſuch caſes, and after trying all the ordinary laxative medicines I could not ſay that any of them was entitled to a preference. The effects of all were temporary only. An ingenious friend and correſpondent in London firſt ſuggeſted to me a trial of calomel in ſuch obſtinate caſes. On his authority I have repeatedly had recourſe to it, and ſeldom without

without the beſt effects. Whether it operates by promoting a flow of bile and other ſecreted fluids into the inteſtinal canal, on which the ſtools of infants, from the nature of their food, muſt very much depend; or by exciting, in a peculiar manner, the irritability of the nerves beſtowed on the inteſtines, I ſhall not pretend to decide.

Of Convulſions in early Infancy.

In the Tranſactions of this Academy for the year 1789 I have given an account of the nine day fits, as they had been obſerved in the Lying-in Hoſpital of this city, and of certain modes of prevention which then appeared to have produced good effects, and which I am happy to add ſtill continue to do ſo*. Of methods of cure I was on that occaſion ſilent, becauſe no remedy had then been diſcovered even to retard the progreſs of that very fatal diſeaſe. About two years ago I was called in conſultation to a caſe of nine day fits, which appeared hopeleſs both to the attending phyſician and myſelf. As an experiment I propoſed a grain of calomel to be given night and morning, knowing it to be well calculated to remove diſ-

* This aſſertion will be beſt underſtood by ſtating the following facts: Previous to the year 1782 the mortality of infants was one in ſix, or ſeventeen in the hundred. From 1782 'till 1788, a period of four years, it was one in nineteen, or from five to ſix in the hundred. During the laſt four years it has been nearly as one to twenty-ſix and a half, not altogether four in the hundred. [See an abſtract of the regiſtry kept in the Lying-in Hoſpital, and annually publiſhed by Mr. B. Higgins.]

eaſe in the bowels, if ſuch exiſted, and a bliſter to the fontanelle to relieve any fulneſs which might oppreſs the brain. By the uſe of theſe remedies, and of tepid bathing, the infant recovered. As bliſters and tepid bathing ſo often fail in curing this diſeaſe, I was inclined to attribute much of our ſucceſs to the calomel, and therefore I introduced the uſe of it in a ſimilar manner into the Lying-in Hoſpital; and although I cannot ſay it actually cured one, yet it certainly afforded more obvious relief than any remedy hitherto tried. Several infants, whom the moſt experienced nurſe-tenders apprehended to be ſeriouſly threatened, eſcaped the diſeaſe; and it evidently mitigated the ſeverity of ſymptoms in ſome deſperate caſes. Whether, in a pure atmoſphere, and ſituations otherwiſe more favourable for the exhibition of powerful remedies, it may be found to produce better effects, I propoſe as a quere, to be determined by future obſervation? In the courſe of laſt month I was ſo fortunate in private practice as to remove convulſions in an infant of three weeks old, by calomel and bliſtering, as above deſcribed, without the uſe of any other remedy*.

Cutaneous Eruptions.

It is a ſingular fact that infants on the breaſt are very ſubject to cutaneous eruptions of the herpetic kind, which in adults are

* Since this paper was firſt read to the Academy, which is near two years ago, I think I have been ſtill more ſucceſsful in the treatment of the foregoing omplaints, by adding to each doſe of calomel a grain or two of ſcammony or jalap, ſo as to render it more certainly and briſkly purgative. *June* 1795.

are commonly ſuppoſed to originate from acrimony in the fluids. It is not eaſy to conceive how acrimony is ſo frequently generated in the blood of infants, nouriſhed by the mildeſt of all fluids. It is a vulgar ſuppoſition that theſe diſeaſes are often occaſioned by improprieties in the diet and conduct of hireling nurſes; but they often happen to infants ſuckled by the mother, where no ſuſpicion of impropriety can be entertained: nay, the ſame tendency is obſerved in infants fed on ſpoon meat. I have been frequently tempted to think that nature intended ſuch eruptions to carry off ſuperfluous or redundant fluids from the conſtitution of infants; hence, perhaps, it is that they are moſt frequently to be met with among large infants, of a full habit. Viewing the ſubject in this light, one would be naturally inclined to encourage the diſcharge from ſuch eruptions; with me ſoap and water is a favourite application; by waſhing off filth, which obſtructs the pores, it allows a free exit both to perſpiration and to the diſcharge from the ulcerated parts; it alleviates the itching, which is not only very troubleſome, but abſolutely injurious to the infant's health, by interrupting its ſleep. All ointments and greaſy applications, having a contrary tendency to ſoap and water, ſeem to me objectionable. By diſcharging freely, the cutaneous complaints under conſideration often run their courſe with ſafety in a few weeks, and the patient is reſtored to health without the uſe of any internal medicine. When, however, the general health ſeems to be impaired, and the violence of ſymptoms renders medicine neceſſary, I have not found any remedy to be put in competition with

calomel, given in the ſame manner as for correcting griping and green ſtools.

Although not immediately connected with my preſent ſubject, it may not be altogether uſeleſs to remark, that along with an herpetic eruption on infants there is ſometimes a mixture of itch which creates a very troubleſome diſeaſe, and one very liable to be miſunderſtood. It is principally by appearances on the nurſe that the exiſtence of itch on the infant can be diſcovered. Herpes on the infant we know generally brings out ſome eruption on the nurſe, but on accurate examination this will be found very different in its progreſs and effects from itch. The mode of curing itch in adults, when diſcovered, is now well aſcertained; but there is great reaſon to doubt whether the ſame treatment be ſafely applicable to infants, and eſpecially when itch is combined with herpes. Coughs of a very dangerous tendency have been obſerved to ariſe after the application of ſulphur ointment to infants. Fortunately there is no abſolute neceſſity for its uſe. Common ſtick brimſtone, bruiſed and boiled for ſome time in water, gives a ſulphureous impregnation, which uſed as a tepid bath every night at bed time ſeldom fails to cure the itch in infants in a few weeks, without any riſk of obſtructing the pores of the ſkin, or of repreſſing too much the herpetic eruption. In all ſuch caſes it is prudent to make the nurſe rub the eruption on her with ſulphur ointment, while at the ſame time ſhe takes flour of ſulphur and magneſia internally, ſo as to keep the bowels moderately open. The infant ſhould

alſo

alſo ſleep in the ſame bed with the nurſe during this operation.

I HAVE thus ſketched, in a haſty manner, the outline of what accident and ſome reflection have ſuggeſted to me on a few ſubjects, in my opinion not perfectly underſtood. To thoſe who know me, hurry of buſineſs (in an irregular and fatiguing profeſſion) will apologize for many defects. The points in doubt regard a numerous claſs of the innocent and helpleſs in the community, who, when ſick, are too frequently entruſted to the care of prejudiced old women, or of men not much better qualified to practice phyſic. I, therefore, entreat gentlemen to enter diſpaſſionately into the inveſtigation of the doubts here ſubmitted to their conſideration. The alleviation of pain, and the prolongation of human life, at a period of its greateſt frailty, are objects ſurely not beneath the notice of any man; and as I pretend not to infallibility, the reader may be aſſured I feel as much intereſted on this occaſion to have *error detected* as to have *truth confirmed.*

A MEMOIR *on the* CONSTRUCTION *of* SHIPS.

By Sir GEORGE SHEE, *Bart. M. R. I. A.*

Read Nov. 1, 1794.

ALLOW me to ſubmit to you a few thoughts on ſhip-building; a ſubject which, from its national importance, would ſeem to claim the attention of the moſt enlightened, but which has heretofore been conſidered by few, except mere mechanics. My motive for addreſſing you is to promote the public good; and as the remarks I ſhall make are more the reſult of obſervation and experiment than of ſcientific reſearch, I am perſuaded you will judge them with indulgence. I ſhould not indeed hazard them but upon the idea that great improvements in the arts have been ſuggeſted by perſons who were not artiſts, and that objects may ſometimes preſent themſelves in a more clear point of view to unprejudiced minds, than to minds much more informed when biaſſed by predilection for eſtabliſhed ſyſtems.

I WAS firſt led to ſuſpect that the conſtruction of ſhips built in Europe admitted of improvement, by obſerving that veſſels

veſſels employed on the river Ganges, and on different coaſts of India, carried great burdens in proportion to their dimenſions; and on examining them I found that, however widely they differed from each other in appearance, great expanſion was common to them all. In order to aſcertain their proportions I had exact models made of ſeveral of them, which I ſhall be happy to ſubmit to the inſpection of your Society. The veſſels of the Ganges, it is true, being conſtructed to move at times in ſhallow water, were not I found well calculated to ſail near the wind; but this defect I knew could be remedied; and it was ſufficient for my purpoſe to aſcertain the fact, that, when even heavily laden, they could be moved with greater velocity than veſſels on the European conſtruction, of the ſame burden, could be by an equal impulſe with ballaſt only on board.

The opinion I had thus formed was ſtrengthened in the courſe of a voyage from Bengal to England. Obſerving that the Rodney, a Company's ſhip, which I was on board of, appeared longer and ſailed faſter than other Indiamen, I made inquiry as to her conſtruction, and was informed that, on laying her keel, ſhe had been intended for a ſhip of much more conſiderable burden, but that, owing to a temporary ſcarcity of timber, all her dimenſions had been abridged, except that her length was ſuffered to remain, and conſequently to exceed by ſome feet the uſual proportion. On our arrival in the channel, with the wind about a point before the beam, we overtook a fleet of Weſt Indiamen, and we outſailed them with ſuch facility

facility that they might almoſt have been ſuppoſed water-logged.

THESE obſervations, with many others, led me to beſtow more attention than I had before paid to an examination of the mechanical principles applied to the building of ſhips; and the more I extended my inquiries, the more I was convinced that their conſtruction was defective: Had, however, my concluſions not been ſtrengthened by previous obſervation, I ſhould not have obtruded them on your attention; for I am myſelf ſo much an infidel in theoretic ſyſtems in general, that I offer conſiderable violence to my mind whenever I ſubſcribe to their truth, unleſs confirmed by ſomething like experimental proof; and I ſhould not therefore expect from others much attention to remarks merely theoretic.

A GLARING defect in ſhips employed in tranſporting merchandize is, that they draw too much water, or are conſtructed too deep. It is well known that every floating body propelled, muſt, in its progreſs, diſplace a body of water equal in weight to itſelf, and in bulk to the part of it ſituated below the ſurface; and that this operation muſt be repeated ſo often as the body moved advances a diſtance equal to its own length. Now as the line of leaſt reſiſtance from the water diſplaced is upwards, it follows that the force neceſſary for its removal muſt be great in proportion to the diſtance of any part of it from the ſurface, and hence ariſes the facility with which veſſels drawing little water are moved, even when the burden they carry is conſiderable.

ANOTHER defect in merchant veſſels is, that they are too ſhort. The progreſs of a ſhip that wants length is impeded by perpetual aſcent and deſcent, even in water but moderately agitated; while one that has it proceeds with little more than direct motion. But this is not the only objection to want of length:—The tendency of the upper ſails of a ſhip is, not only to propel horizontally, but, in a very conſiderable degree, to preſs down the head and elevate the ſtern, as will appear evident when it is conſidered that the maſt is acted upon as a lever, the upper deck is the fulcrum, and the parts above and below it the two arms. Now the action of the wind that fills the upper ſails is nearly upon the point of the long arm, and the degree of reſiſtance to the depreſſing force ſo cauſed is determined by the length of the line from one extreme horizontal point of the ſhip to the other; when therefore this line is ſhort, in proportion to the height of the maſt, the effect is not only evident in a high or ripling ſea, with the wind fair and ſtrong, but even in ſmooth water, the veſſel, particularly if ſmall, proceeds with evident deviation from the horizontal poſition which her hull is intended to preſerve, as well when in motion as at anchor; and by this means the points of direct reſiſtance are multiplied, as the height of the frothy wave at the bows of ſuch veſſels in their progreſs, or the diſproportion of that wave to their velocity, ſhape and ſize, evidently ſhews.

A THIRD defect too, not leſs ſtriking than theſe, is that the veſſels I mention are too narrow. A few feet of length add

add little to the ſize of ſhips as to burden, but a ſingle foot in breadth increaſes prodigiouſly their capacity to ſuſtain weight. The ſhape of merchant veſſels in general may be ſaid, from its tendency, to reſemble an extended wedge perpendicularly placed; every ton additional weight preſſes them down conſiderably, and from the practice of overloading them, in order to proportion their burden to their ſailing charges and original coſt, they commonly proceed on a voyage almoſt buried in the water. To this circumſtance alone the loſs of numbers of them may be aſcribed; for a captain muſt be poſitive that the danger is exceſſive before he can hold himſelf juſtified in attempting to lighten the ſhip; and in ſituations the moſt perilous this is often found impracticable.

The remedy for theſe defects is eaſily ſtated, but the practicability of applying it requires explanation, as inveterate prejudices in the minds of ſhip builders are to be oppoſed, and ſtrong prepoſſeſſions, in the minds even of men of ſcience who have thought mechanics deſerving their attention, to be combated.

To give ſhips great horizontal expanſion, in proportion to their depth, which I conceive eſſential to the perfection of their form, the conſtruction of their hulls, in other reſpects, muſt undergo a change. The bow and the ſide are, or rather ought to be, conſtructed upon principles directly oppoſite. The one is to break through the water, the other to reſiſt all force that gives the body of the veſſel a diſpoſition to lee-way. The per-

fection of the former is to have as few points of direct reſiſtance as poſſible, that of the latter, it would ſeem, to preſent as many; muſt it not then, to an unprejudiced obſerver, appear extraordinary that both parts ſhould be compoſed of ſegments of circles, ſcarcely a ſuperficial ſquare foot of the largeſt ſhip's ſide, below the water mark, lying perpendicular to horizontal preſſure. The keel, in fact, with ſome ſmall extent of plain immediately above it ſpringing from the bottom, are truſted to for reſiſtance, and theſe are in moſt caſes inſufficient, few veſſels, except frigates and others of extraordinary length, being found to ſail well upon a wind.

An argument univerſally uſed by ſeamen and ſhip-builders, in ſupport of the preſent conſtruction as to depth, is, that what they technically call "a gripe of the water below the power "of the ſurge," is eſſential in preventing veſſels from being driven to leeward.—As this argument, if ſound, ſtrikes directly at the root of any improved ſyſtem founded on expanſion, it is neceſſary that it ſhould not remain unanſwered.

A gripe below the influence of the ſurge, if it mean any thing, implies reſiſtance to the force of waves beating againſt a ſhip's ſide. Now ſuppoſing this reſiſtance poſſible, the firſt high ſea that ſhould ſtrike her on the beam, in a gale of wind, would inevitably either overſet her or deſtroy her by forcing in her ſide; the ſecurity therefore of ſhips, in numberleſs caſes that conſtantly occur, depends on their yielding to the force of waves. Admitting however, for argument-ſake, that, in ſtorms, the

the dexterity of ſeamen may prevent a ſhip from being expoſed to the violence of the ſea upon her broad ſide, let us ſee how, in moderate weather, the deep gripe can operate.

Waves, I believe, are not thought to run very high when they riſe from ſix to ten feet above the water level; that is from twelve to twenty above the trough of the ſea:—there are few ſhips whoſe draught of water exceeds twenty; is it not evident then, that through all gradations of ſize, veſſels, even on their preſent conſtruction, are in general completely expoſed to the power of the ſurge.

But, as experiment ſuperſedes argument, any perſon in whoſe mind doubts exiſt upon this ſubject, may ſatisfy himſelf by viewing a ſmall cutter, when ſailing upon a wind, in company with large ſhips; or by obſerving a wherry, which draws ſtill leſs water, working to windward: Nay, even a ſhip's long-boat, the moſt flat of all ſea veſſels, may ſerve to convince him that he may diſmiſs thoſe doubts without running much riſk of falling into error, and ſatisfy him that, provided a veſſel have hold of the water proportionate to her ſize, it is of little moment whether the gripe be near to or remote from the ſurface.

The improvements then which I beg leave to recommend in the conſtruction of merchant veſſels are, an increaſe of their horizontal, and a reduction of their perpendicular dimenſions, which will correct the three defects I have pointed out; alſo the

the alteration in the ſhape of their ſides and bows, which I have already ſaid is neceſſary, in order to render theſe improvements practicable.

WERE the length of the keel even ſo far extended as that it ſhould reach two perpendicular lines dropped from the extreme points of a ſhip's upper deck, the increaſe of gripe would be prodigious, and the additional expenſe trifling. A ſheer or projection abaft is unqueſtionably beautiful; but it is of no uſe, and the eye would ſoon become reconciled to an upright ſtern. The ſheer, however, might be given with any length of keel, where expenſe ſhould be diſregarded, unleſs it ſhould be thought, which I am rather inclined to believe, that a very long veſſel would be weakened by it, for the ſtrain upon a ſhip's centre is in fact reſiſted more by the binding of her upper planks and timbers than by the ſtrength of her keel. The expenſe of this increaſe of length, together with that attending the increaſed breadth of the veſſel, would nearly be paid by the ſaving cauſed by the reduction of her depth.

THE alteration in the form of the ſides and bows needs a few words more of explanation.

THE effect to be expected from a flat ſide is exemplified in an ingenious contrivance uſed to ſupply want of depth in Dutch veſſels of various deſcriptions; and I cannot give a more correct idea of the improvement in this reſpect I wiſh to recommend, than by ſaying that the ſide of a ſhip, below the water

water level, or a part of it at leaſt, ought to reſemble a *lee board* of conſiderable extent. By means of this board many Dutch merchant veſſels, notwithſtanding they are conſtructed with a floor almoſt flat to fit them for great burden and ſhallow water, are found to ſail tolerably well upon a wind, and yet they are in general ſhort, with bluff upright bows, and many other defects.

Dutch fiſhing veſſels too, particularly thoſe employed in great numbers on the coaſt of England, are rendered by the uſe of a lee board good ſailers. Not being intended for burden they do not in general much exceed boat ſize; and although they are the moſt flat of all decked veſſels I have ſeen, their ſecurity in blowing weather is proverbial.

Now in reſpect to the bows of merchant ſhips, I will only obſerve, that although they ſlope off tolerably well when veſſels are light, they preſent, when laden, ſuch reſiſtance to head way as can ſcarcely be overcome by any preſſure of ſail. The evident remedy is to render them leſs upright; expanſion in them, although abſolutely neceſſary above the water level, being quite uſeleſs below it.

By adopting theſe improvements I am perſuaded that the ſame quantity of timber and other materials now employed in building a merchant veſſel of one hundred tons burden, would ſerve to form one capable of carrying at leaſt one hundred and thirty, and that the velocity gained would rather exceed this

this proportion. The advantage of performing three voyages in the uſual time of two, or even ſuppoſe five in the time of four, need not be ſtated; nor need that which would reſult, in the ſeaſon of tempeſt, from reducing the length of time in which ſhips are expoſed to danger, or in time of war from rendering them capable of evading purſuit.

The conſtruction of veſſels employed in carrying mails between Dublin and Holyhead I conceive to be nearly as defective as that of merchant ſhips, which their hulls in a great meaſure reſemble, although they are built expreſsly for ſpeed and accommodation, and not burden. But indeed burden they do carry; for, from their deep form, they require an abſolute loading of ballaſt to prevent them from overſetting; and their draught of water is ſuch, although ſmall veſſels, that they can float on the Dublin Bar only at a particular time of tide, by which fair winds are frequently miſſed, and the paſſage from England unneceſſarily prolonged. From their want of length and exceſſive depth they are ſuch ſlow ſailers, that the Favourite, a light long veſſel, fitted out by private individuals, has made her paſſage to Holyhead in nine hours, when two packets, which weighed anchor when ſhe did, took twelve to perform theirs.

In determining the moſt proper conſtruction for theſe, or indeed any other ſea veſſels, it ſhould be conſidered that the greater the length the leſs depth will be neceſſary to prevent lee way; and that the greater the breadth, the more ſail may be

be carried, and the leſs ballaſt required. Weight it is true does not operate exactly upon ſhips as burden does upon animals; its ſituation, as I have already ſaid, determining in a great meaſure the reſiſtance to velocity it cauſes; but that its operation is conſiderable cannot I believe be doubted. In ſhort, I am perſuaded that packet veſſels might be conſtructed on a principle ſo light, that they might paſs the Dublin Bar at any time of tide, ſo ſpeedy, that they would commonly perform their voyage in three-fourths or perhaps two-thirds of the time thoſe in uſe now employ; and at the ſame time that they would, if poſſible, be more ſafe, and certainly much more commodious, their building and ſailing charges would not be more conſiderable.

To determine the exact extent to which the improvements I recommend can, in general, be practically applied, is not my preſent object. I only mean to ſuggeſt hints which, if thought deſerving of the trouble, may eaſily be thrown into regular ſyſtem; and I will cloſe an addreſs, imperceptibly extended beyond its intended limits, with a word on ſhips of war.

Should theſe improvements prove founded on true principles of naval architecture, their application may certainly be extended to the conſtruction of frigates and all other King's ſhips carrying one tier of guns only; but that thoſe of two and three tier can, in an equal degree, be improved, is an aſſertion I will not hazard. The effect of the weight the latter carry above water muſt be counteracted by a proportionate

weight below it, and it is poſſible that an increaſe of their horizontal expanſion would be unſafe, conſidering that timber beyond the preſent dimenſions cannot well be procured. Determinate flatneſs of ſide, however, for ſome diſtance below the ſurface of the water, would aid very conſiderably in reſiſting the effect of a ſide wind on ſo prodigious a ſurface as their hulls preſent above water, and even a very trifling addition to their breadth of beam would probably enable them to carry their guns better than they now do in a high ſea, and render ſome reduction of their draught of water practicable.

That light frigates might be made capable of receiving as great velocity from a moderate breeze as is now given them by a ſtrong wind, is a truth I am perſuaded of; and that the utmoſt velocity any veſſels are capable of is not yet attained in the European ſeas, is a fact that will not be doubted by any perſon who credits the well authenticated accounts given of flying prows. The form of theſe veſſels it is true unfits them for any other ſea but that in the latitude of the Ladrone Iſlands, but uſeful hints may notwithſtanding be taken from their conſtruction.

MEMOIR *on the* CLIMATE *of* IRELAND. *By the* REV. WILLIAM HAMILTON, *of Fanet, in the County of Donegal; late Fellow of* TRINITY COLLEGE, *Dublin; M. R. I. A. Correſponding Member of the Royal Society of Edinburgh, &c.*

Read Dec. 6, 1794.

IT is generally ſuppoſed that the ſeaſons, in our iſland, have ſuffered a conſiderable change, almoſt within the memory of the preſent generation. The Winters of our climate are ſaid to have laid aſide their ancient horrors, and frequently to have aſſumed the mildneſs and vegetative powers of Spring; while Summer is repreſented as leſs favourable than heretofore; leſs genial in promoting vegetation, and leſs vigorous in forwarding the fruits of the earth to maturity.

IT is indeed true that, in this inſtance, popular opinion does not ſtand ſupported by the concurrent teſtimony of meteorological obſervations: There is no clear evidence derivable from them, that the preſent ſeaſons are materially different from former ones;

and therefore philoſophers and meteorologiſts naturally aſcribe to the querulous diſpoſition of the farmer the chill ſenſations of old age, or the predilection which every one feels for the chearful days of childhood, the adoption of an opinion that ſeems ſo eaſily to flow from theſe ſources.

But let it be remembered that the inſtruments of atmoſpherical obſervations do not extend to *all* the circumſtances, which influence the crops of the farmer, or the ſenſations of the man. The thermometer may mark the general temperature of our climate as unchangeable; and the pluviometer may aſcertain its uſual moiſture; whilſt a clouded atmoſphere, or a tempeſtuous wind, ſhall mar the progreſſive maturity of harveſt, and ſhatter the languid frame of declining age.

Heat and cold, and rains, are indeed principals in the œconomy of ſeaſons; but winds, clouds, vapours, and other circumſtances rarely regiſtered, often unperceived, are to be deemed at leaſt ancillary in the extenſive ſyſtem; and may give plauſibility to popular ſenſations and opinions, even without the aid of meteorological teſtimony.

It is the purpoſe of this paper to offer to the Academy ſome obſervations relating to this intereſting ſubject; and to mark a few prominent events in the phænomena of our climate, which may add credibility to general report.

Of

Of the Winds and their Effects.

THE winds, which moſt uſually prevail in our latitudes, blow from the Weſtward, for reaſons unneceſſary to be detailed here. Theſe winds are commonly mild in their temperature, and moiſt in their nature. They are, from theſe properties, extremely friendly to animal and vegetable life; and to them the great population of Ireland, and the uncommon fertility of its ſoil, may, among natural cauſes, be aſcribed.

BUT, from whatever circumſtances it has ariſen, theſe winds have, of late years, ſwept with uncommon violence over the ſurface of our iſland; fruſtrating the uſual effects of their genial properties by the overbearing fury of their courſe; and, like Saturn, ſometimes devouring the offspring to which themſelves had given birth.

WHY theſe weſterly winds have ceaſed to bear the character of zephyrs may admit of much curious and intereſting inveſtigation: at preſent I ſhall be ſatisfied with endeavouring to eſtabliſh the fact itſelf, by ſuggeſting to the Academy ſome circumſtances that ſeem to determine the matter with a very great degree of probability.

THE effects of theſe winds are marked, in viſible characters, over the whole ſurface of the kingdom; but they are peculiarly diſtin-

diſtinguiſhable in the northern province of Ulſter; and chiefly in the extreme counties of that province, where a northerly latitude, joined to an expoſed ſituation on the coaſts of the ocean, forms an apt ſtation for obſervations, and exhibits, as it were on a magnified ſcale, the degrees of the phænomena themſelves.

THREE natural regiſters of theſe effects have come within my obſervation; the trees of the country, the ſands of the ſea coaſt, and the tides of the ocean: Of each of theſe I ſhall make mention in its order.

Of the Trees.

IT is a fact extremely well eſtabliſhed, that the pine tree, and peculiarly that ſpecies vulgarly denominated the Scotch fir, formerly grew on many of the mountains of this kingdom, and on parts of the northern and weſtern coaſts, exceedingly bare and open to ſtorms. Vaſt roots, and noble trunks of this ſpecies of pine have been ſeen and examined by me with attention, in ſituations where human induſtry cannot now rear a twig of the hardieſt tree. On the higheſt lands of the general ſurface of the kingdom, in the county of Weſtmeath, amid the mountains of the county of Antrim, and on the naked coaſts of Eniſhowen, and Roſſes, in the county of Donegal, pine trees have formerly arrived at an age of an hundred and twenty years, have grown to the ſize of a yard in diameter, and ſurpaſſed fifty feet in height.

THERE

THERE is great reaſon to think, that two centuries have hardly elapſed ſince many of theſe trees grew in thoſe ſituations; and probable reaſons might be adduced, to limit the great period of their deſtruction to the age of James the firſt of England; in whoſe reign rewards were held out for ſettling the kingdom, and clearing its ſurface of foreſts, which, under favour of inceſſant wars, and neglected tillage, during a period of eight centuries, had overſpread the face of the country *.

THE harſh and furrowed bark of this pine has occurred to me, in ſuch a perfect ſtate of preſervation, as almoſt alone to determine its ſpecies †.

THE cones have been found by me at a depth of many feet from the ſurface of the earth, in ſuch condition as almoſt to give hope of raiſing plants from their ſeed ‡. Marks of the woodman's hatchet

* "In this reign pipe-ſtaves was one of the ordinary exports of Ireland; ſo that "a mighty trade was driven with them, and thouſands of trees were felled, every "year, for this purpoſe. A multitude of iron-mills were erected; and it is in- "credible how much charcoal a ſingle iron-mill will conſume in one year. So that "all the great woods, which the maps ſhew us on the mountains, between Dundalk "and Newry, are quite vaniſhed, except one tree, cloſe to the highway, at "the very top of the mountain, which, as it may be ſeen a great way off, therefore "ſerveth travellers for a mark."

"Yet there are ſtill great woods remaining in Dunnagall, in Tyrone, in Antrim, "&c." See Nat. Hiſt. of Ireland by Boates, Molleneux, and others, written about the middle of the laſt century.

† In Bracknaheevlin bog, county of Weſtmeath.

‡ In Lackbeg bog near Rutland, county of Donegal.

hatchet on their trunks; veſtiges of fire applied for their deſtruction; the pieces of charcoal into which many of them have been burnt *; paleings, and ſmall encloſures, found at the level where they have formerly grown †; all ſeem to prove the interference of human induſtry in the extirpation of theſe noble trees, and even to aſſign no very remote period for that event.

Leathern ſhoes, wooden veſſels filled with butter, and other light ſubſtances, found at conſiderable depths in turf-bogs ‡, and not likely to have deſcended through the matted texture of that ſubſtance, give additional teſtimony to the opinion, that the exiſtence of theſe bogs, and, of courſe, that of the trees which they contain, is not of an extremely ancient date.

It is needleſs to recal the attention of the Academy to the difficulty of raiſing trees, at preſent, in many of thoſe ſituations where the ancient pine and oak of Ireland have, within the period of human exiſtence, flouriſhed with luxuriance.

The

* Found in a bog in the liberties of the city of Londonderry.

† In a bog near Surock, county of Weſtmeath: near Kilruſh, county of Clare; at Carniſk, near Ramelton, county of Donegal.

‡ Omitting other inſtances: Two wooden veſſels, containing butter, were very lately found deep in a turf-bog, in the Fews mountains, near Ballymoire, the ſeat of Sir Walter Synnott. The veſſels were extremely inartificial, being little better than the hollow trunks of ſome large ſpecies of willow: the butter was inſipid, inodorous, colourleſs, ſomewhat reſembling unctuous white ſteatites in its touch and appearance; but its inflammability remained ſo perfect, as to admit of its being made into candles, to which uſe much of it was applied.

The labours of the farmer, the reſources of wealth and information, the rewards of patriotic ſocieties, and even the liberal encouragement of the legiſlature itſelf, have in vain ſtruggled againſt the weſtern ſtorms, during the latter part of the preſent century; and the planters of our age, wearied with combating the tempeſt, have generally found it neceſſary to fly from all elevated and expoſed ſituations, and to abandon the pleaſing idea of covering the nakedneſs of mountains, the ſterility of rocks, and the bleak uniformity of bogs, with the luxuriant foliage of the oak and the pine.

Of all the foreſt trees, which, in later times, have been cultivated for general uſe, there is none higher in the eſtimation of our farmers than the aſh. It is a tree which buds late, but finally iſſues forth ſtrong and ſucculent ſhoots: ſecure, by its deciduous nature, from wintry blaſts, it is, nevertheleſs, extremely ſenſible to the efforts of ſummer ſtorms; and becomes a faithful regiſter of the winds of our climate, marking their moſt prevalent direction by the inclination of its boughs, and their violence, by the degree wherein its tender ſhoots, or more mature branches, are withered or blaſted.

Half a century has ſcarce elapſed ſince this uſeful ſpecies of tree was generally planted, and grew luxuriantly in every part of Ireland: yet are there hardly any expoſed places in the kingdom where its top branches do not now, in one part or another, exhibit the withered veſtiges of commencing decay. Through

many parts of Ulſter it is a blaſted tree; and in all unſheltered ſituations, in the three northern counties of Antrim, Derry, and Donegal, the ſpecies ſeems faſt verging toward annihilation *.

Attentive to each prognoſtic of the ſeaſons, alive to every circumſtance whereon the future ſubſiſtence of his numerous family, in a populous country, may depend, the farmer of the north ſees theſe veſtiges of the tempeſt with ſolicitude; and often taught, of late, to dread the effects of ſummer ſtorms on his luxuriant crops of potatoes, he has become querulous from experience, and thinks he has ſome reaſon to complain that the ſeaſons are leſs favourable to his hopes than formerly; that the pine tree has not forſaken the mountains, nor the aſh been blaſted in his fields, without the influence of encreaſing tempeſts.

Of the Sands.

The waſte and dreary ſolitude of extended barren ſands, which almoſt every ſea-coaſt exhibits, is generally paſſed over with rapidity, as uſeleſs to the philoſopher, from the incalculable fluctuation of its ſurface; and weariſome to the traveller, by its diſguſting uniformity.

Yet, in the midſt of ſuch a ſterile ſcene, where nothing occurs to divert the path, or diſtract the penſive mind of the traveller, if traces of human exiſtence ſhould ſuddenly become viſible, if encloſures

* In Lancaſhire in England, between Garſtang and Preſton, the trees are alſo cut off by the weſterly winds. See Newte's Tour, year 1791.

encloſures ſhould appear to mark the chearful fire-ſide of ſome former villager, or the circuit of his little garden; if embattled walls, or marble piers ſhould ſtart up amid the ſands, ſuggeſting ideas of ancient elegance and feſtivity, he muſt have a ſtoic's mind, indeed, who will not venture to calculate cauſes, and feel intereſted in events that come home ſo cloſely to the human heart.

On many parts of the coaſt of Ireland ſcenes, ſuch as theſe, may be diſcovered.

At the entrance of the river Bannow, in the celebrated barony of Forth, in the county of Wexford, veſtiges of ruins, traced with difficulty amid heaps of barren ſand, ſerve to aſcertain the ſite of a town, whoſe ancient reſpectability was marked by the royal charter, which endowed it with the privilege of ſending repreſentatives to the parliament of the nation, and whoſe opulence may be inferred from the ſtreets which are regiſtered in the revenue records of the laſt century *.

* "So late as the year 1626, Bannow is regiſtered in the cuſtom-houſe books of Wexford, as having four ſtreets which paid quit-rent to the crown; viz. Lady-ſtreet, High-ſtreet, Weavers-ſtreet, Little-ſtreet, and ſome buildings ſurrounding the church. The only remains of Bannow, which ſtand viſible at this day (1786), are the walls of its church. There is not on or near the town but one poor ſolitary hut. The election for the repreſentatives of the town is held on the walls of an old chimney, adjoining to the church, which tumbled down piece-meal, and forms the council table of that ancient and loyal corporation."

Private letter of a friend in the county of Wexford.

Amid the ſands between Portruſh and Dunluce, in the county of Antrim, in the year 1783, the ruins of a village might be ſeen, deſerted by its inhabitants, who had been obliged to move further into the country.

In the year 1787 the peninſula of Hornhead, in the county of Donegal, contained veſtiges of encloſures, ſo ſmall, and ſo numerous, as to mark the reſidence of a conſiderable number of human families, in a ſpot which then exhibited nothing, but

——— " a deſert, ſalt and bare,
" The haunt of ſeals and orcs, and ſea-mews clang."

Milton.

Somewhat about a century ago the peninſula of Roſsgull, lying between the harbours of Sheep-haven and Mulroy, in the county of Donegal, was ſelected as the reſidence of one of the noble families of Hamilton, titled Boyne. It is to be preſumed there was then but little apprehenſion that the elegant edifice of that age ſhould, after the ſhort interval of an hundred years, ſtand, like Tadmor of the Eaſt, the ſolitary wonder of a ſurrounding deſert.

For the age wherein it was built, and the ſtyle of architecture of that day, the manſion of Roſeapenna may be called elegant. The approach was from a level green on the ſhore, through a ſucceſſion of embattled courts, and hanging terraces, riſing in order one above the other, and adorned with marble piers of no mean deſign and workmanſhip.

The

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The rear was ornamented with gardens, laid out and planted in the faſhion of the laſt century; and the parks and fields of the demeſne ſeem to have been well divided and encloſed.

At preſent every object in this place preſents to view peculiar characters of deſolation. The gardens are totally denuded of trees and ſhrubs, by the fury of the weſtern winds: their walls, unable to ſuſtain the maſs of overbearing ſands, have bent before the accumulated preſſure, and, overthrown in numberleſs places, have given free paſſage to this reſtleſs enemy of all fertility. The courts, the flights of ſteps, the terraces, are all involved in equal ruin; and their limits only diſcoverable by tops of embattled walls, viſible amid hills of ſand.

The manſion itſelf, yielding to the unconquerable fury of the tempeſt, approaches faſt to deſtruction: The freighted whirlwind, howling through every avenue and crevice, bears inceſſantly along its drifted burthen, which has already filled the lower apartments of the building, and begins now to riſe above the once elevated threſholds. Fields, fences, villages, involved in common deſolation, are reduced to one undiſtinguiſhable ſcene of ſterile uniformity; and twelve hundred acres of land are ſaid thus to have been buried, within a ſhort period, in irrecoverable ruin *.

Hence

* It would be teazing to dwell on a repetition of ſimilar examples. I ſhall juſt mention two others. In a ſummer excurſion from College, in the year 1787, paſſing from

Hence it appears, that intereſting natural events, the conſequence of ſtorms, have occurred on our coaſts in the latter part of the preſent century, which were not foreſeen, nor even ſuſpected, at its commencement.

Of the Tides.

It cannot be wondered at if theſe tempeſts ſhould have had conſiderable effect on the tides of the ocean. The waters of that element, as long as they are unimpeded by extraneous cauſes, obey the influence of the heavenly luminaries, and ebb and flow with degrees of quantity, and regularity of periods, which come within the reach of human calculation. But when they are agitated by ſtorms,

from Dunfanaghy to Rutland, along the weſtern coaſt of Donegal, I had great difficulty to diſcover a houſe, ſituated between the river Guidore and the Roſſes iſlands, whither I had been directed to enquire for a guide; and, after much ſearch, at length perceived its roof, juſt emerging from the ſands. The owner told me that his houſe was not long built, and had, at firſt, a conſiderable tract of paſture ground between it and the ſea ſhore, but that, of late, he was every year obliged, with great labour, to dig it out of the encroaching ſands, and purpoſed, ſhortly, to remove it to the oppoſite ſhore of a lake called Mullochdearg, which lay behind the houſe, in deſpair of being able to maintain his preſent ſituation.

A diſputed boundary in Fanet, on the northern coaſt of the ſame country, between the tenants of one of my own glebes and the neighbouring peaſants, is aſcertained by a heap of iron ſcoriæ in the midſt of looſe and ſhifting ſands. Thirty or forty years ago there ſtood here the forge of the village; but no remains of it, or its ſmith, are now diſcoverable, except the cinders of the forge, and the rank weeds that ſpring from a rich ſtratum of earth, once the ſoil of his garden, and ſtill viſible in a hillock of ſand.

ſtorms, or other violent convulſions, their quantities, and periods, become altogether uncertain and incalculable.

Generally ſpeaking, agitation of the ocean, from whatever cauſes it may ariſe, produces encreaſe in the influx and reflux of its tides, as well as deviation from their calculated times; and where the movement of this extraneous influence coincides with the natural direction of the waters, the effects are viſibly diſtinguiſhable by the traces of inundation which attend their unuſual progreſs.

As the tides of our coaſt, raiſed in the Atlantic ocean, flow in upon us from the weſtward, a ſtorm from that quarter invariably gives them an uncommon elevation in our harbours: and this accumulation of waters ſometimes anticipates even the tempeſt itſelf, becoming the forerunner and prognoſtic of its diſtant commencement, and approaching impetuoſity.

Of late years, theſe extraordinary influxes of the ocean have been much greater, and more frequent, than formerly. Every perſon on our coaſts, whoſe ſituation has made the conſtruction or preſervation of embankments againſt the ſea neceſſary, knows, by painful experience, how much his labours have, of late years, encreaſed, and how impotent works, formerly effectual, are now found to be, in repelling the encreaſing tides of the preſent day. Public roads encroached on; walls beaten down; ſtrands leſs paſſable than heretofore; meadow and tillage land oftener, and more

more deeply inundated; all concur to prove encreaſing tides, and frequency of ſtorms on our coaſts.

These phænomena faithfully regiſtered, extenſively and diſtinctly delineated in natural characters, independent of every bias from human ſyſtem or prejudice, free from the uncertainty of caſual records, or the locality of peculiar ſtations for obſervation, ſeem directly to demonſtrate an unuſual and encreaſing violence in the winds of our climate during the preſent century. That theſe tempeſts have chiefly borne upon us from the weſtward, is plain from the ſame general appearances: for, where local circumſtances have not directly interfered in oppoſition, the trees, ſhrinking before the preſſure from the ocean, have univerſally yielded to the weſtern blaſt. The ſands have drifted, and the tides ruſhed upon us from the ſame quarter, evidently demonſtrating the more frequent recurrence, and ſuperior potency, of the Atlantic ſtorms.

Of the Effects of theſe Weſtern Tempeſts on the general Temperature of the Climate.

In a paper, honoured with a place in the ſecond volume of the tranſactions of the Academy, I recorded the reſult of ſome experiments made in the year 1788, for the purpoſe of aſcertaining the temperature of the earth in our latitudes.

From theſe experiments it appears, that the medium temperature of the kingdom of Ireland, from its ſouthern to its northern

ern extremity, nearly coincides with the ſtandard aſſigned to correſpondent degrees of latitude in Mr. Kirwan's ingenious tables *.

It is further diſcoverable, that the general warmth of our iſland is in no reſpect inferior to that of other countries in its parallel: from whence we are naturally led to conclude that the annual quantity of heat received here, is not leſs, in our day, than it was in former ages.

If theſe things are ſo, it may be denied that there is any ſubſtantial foundation for the frequent complaint of change in our ſeaſons. The ocean may be agitated by ſtorms, ſands be drifted along our coaſt, and trees blaſted in mountainous and expoſed ſituations;—but why ſhould the farmer lament the diminiſhed ardour, and ſhortened period of his ſummers; as if winter poſſeſſed more than its natural portion of the revolving year? Whence ſhould ariſe the gardener's complaints, that his peaches, however ſheltered from ſtorms, rarely now arrive at maturity, and that his May-duke cherries, even in the moſt favoured aſpects, no longer merit that diſtinguiſhed title?

May I be permitted to aſſume, as true, the fact which it has hitherto been the purpoſe of this paper to demonſtrate, and in ſupport of which the trees, the ſands, and the tides of our iſland, ſeem to bear conſiſtent and unequivocal teſtimony; namely that,

* See Kirwan's Eſtimate of Temperatures.

of late years, the weſtern winds have blown with encreaſed violence. From that ſingle principle an anſwer may be deduced to all theſe intereſting queſtions.

It is a matter well known, and eaſily to be explained, that the ſurface of the ocean varies leſs from the mean annual temperature of its latitude than land in the ſame parallel * : that is, the ſurface of the ſea is colder in ſummer, and warmer in winter, than the ſurface of the ground in that latitude.

If then the prevalent winds of any country blow over an ocean ſituated in its parallel, that country will relatively be denominated temperate ; it will be free from all extremes ; the heats of ſummer, and the colds of winter, will be checked by ſea breezes of a contrary property ; and the land, influenced by the neighbouring element, muſt, more or leſs, partake in its equability of temperature.

Such is the caſe in almoſt all the iſlands of the world ; and ſuch, from immemorial ages, has been the peculiar character of Ireland. Hither come the weſtern winds, modified by the temperature of the broad Atlantic ocean which they traverſe in their career : Hither fly the clouds, teeming with moiſture collected in a courſe of three thouſand miles along its ſurface : and here uniformity of temperature, and redundant humidity, have always been marked as the diſtinguiſhed character of our ſoil.

Since

* See Kirwan's Eſtimate of Temperatures.

Since then the trees, the ſands, and the tides demonſtrate that theſe winds have, of late years, blown with unuſual violence; ſince they bear teſtimony that a large quantity of air, thus directed, thus tempered and ſurcharged, has paſſed over our lands; it plainly follows that the climate muſt have felt the change; that it muſt have experienced colder ſummers and milder winters than heretofore, approaching towards that equability of heat, and redundance of moiſture, which the farmer and the gardener at preſent ſo heavily lament.

But it is not from encreaſe of quantity alone that theſe winds have produced their effects. They have altered the temperature of the ocean itſelf; and thus have, as it were, multiplied their changeful influence on the land; acting there, at once, with new properties, as well as with encreaſed quantity.

The ſurface of water, in a ſtate of tranquillity, admits of greater variations of temperature than in a ſtate of agitation. It may become much hotter in ſummer, and colder in winter, when calm, than when diſturbed: for the particles at the ſurface, when heated or cooled, do not immediately give place to others nearer the bottom; the proceſs of commixture, in a tranquil ſtate, is gradual, and the tranſmiſſion of change ſomewhat reſembles the ſlow and retarded progreſs that takes place on the land. Agitation always counteracts this gradual proceſs; a rapid commixture of the particles produces a quick aſſimilation of temperature throughout the whole maſs, and thus, taking away all partial exceſs, reduces the whole toward a medium ſtate of uniformity.

THUS ſummer tempeſts always tend to diminiſh the ſuperficial heat of an ocean over which they ruſh; while winter blaſts, agitating the waters at conſiderable depths, reſiſt the natural cold of the ſeaſon by a ſupply of relatively warm particles, which ariſe from the bottom toward the ſurface.

THAT the Atlantic ocean, the vaſt and potent arbiter of our ſeaſons, has ſuffered unuſual agitation of late years, ſeems evident from the natural phænomena recorded in the beginning of this Memoir. The trees, and ſands of our iſland, bear teſtimony to the ſtorms which ſweep along its ſurface; and the tides come to us as frequent, and unerring meſſengers of the tumultuous and agitated ſtate of its billows, attendant on their furious career.

FROM this perturbed abyſs of waters has ariſen an unceaſing influence, equally potent to check the ardour of the ſummer ſolar beams, or to relax the ſhackles of a northern winter. By this prevailing influence ſummer has been rendered impotent to raiſe and ripen many of our crops, and the farmer, taught by neceſſity, learns now to hand them over ready grown, and prepared for the maturity of ſummer, under the mild temperature of an Atlantic winter. Hence too the gardener has, of late years, been compelled to call in the aid of artificial heat to forward the peach, the nectarine, the grape, and every other ſpecies of delicate fruit, to perfection.

HENCE

HENCE premiums now vainly tempt the growth of hemp, which formerly peaſants, in the moſt northern counties in Ireland, cultivated without reward around their cabbins for domeſtic uſe: And hence the ancient apiaries of our iſland, once ſo celebrated, and guarded with ſuch ſpecial and minute attention by the Brehon laws *, are now extinct; and honey, from being a common article of popular conſumption, has become a rare luxury, or an expenſive medicine.

WINTER has likewiſe felt the general influence of this Atlantic temperature; our graſſes ſcarcely droop beneath the froſts; wheat and oats vegetate in the open fields during the very ſolſtice itſelf; myrtles and laurels, in ſheltered ſituations, brave the ſeverity of winter: The Foyle, and other large rivers of the northern province, frequently ſubject to the icy chains of former ages, now run in uninterrupted freedom †.

FACTS, ſuch as theſe, are to be conſidered as the baſis of general opinion concerning the alteration of our climate; while old age, connecting theſe appearances with the fragility of declining life, and a decayed conſtitution, has become querulous in proportion to its feelings, and, judging of external phænomena by the exaggerated teſt of its own acute ſenſations, emphatically pronounces, that the ſeaſons are now leſs favourable than formerly.

On

* See Collectanea de Reb. Hib. Tranſl. Brehon Laws.

† Fifty years have elapſed ſince the River Foyle has been effectually frozen over at Derry: It is alſo obſerved, that the River Thames, in Britain, is leſs frequently frozen of late years than formerly. See Archæologia Britannica, vol. iii. p. 55.

On the Conſequences of this Equability of Temperature to animal and vegetable Life.

FROM the tranſient peruſal of this Memoir, a rapid and impatient mind would probably draw numberleſs falſe concluſions. The facts here recorded ſeem to wear a gloomy aſpect; to mark a gradual deterioration of our ſeaſons; to indicate a climate, harſh, ungenial, and of conſequence ſterile in its nature; clouded, humid, tempeſtuous; cheerleſs, and unfriendly to animal and vegetable life.

ALL theſe concluſions contradict experience, and may be overturned by a calm conſideration of the phænomena themſelves.

EXPERIENCE teaches us that dry ſeaſons, and eaſterly gales, are, in our iſland, invariable ſources of feeble vegetation, and numerous diſeaſes*; and the hiſtory of the world informs us that winds, whether hot or cold, are in their nature deleterious to animal and vegetable life, in proportion as they become deprived of humidity. The warm air of the African deſert breathes deſolation over the parched land of Egypt and Syria, before it is yet felt as a tempeſt †. Even our own weſterly winds, the Atlantic meſſengers of health and fertility to our iſland, after traverſing the cold and dry tract of the vaſt Siberian continent, bear nothing but ſterility,

* Of this the Influenza, attendant on the eaſterly winds of ſpring, in the preſent year (1795) affords a ſtrong inſtance.

† See Volney's Account of Egypt and Syria.

rility, and almoſt perpetual winter, to the unhappy climate of Kamſchatka *.

Heat or cold in extremes; dry air in rapid motion, and moiſt air in a ſtagnant ſtate, ſeem to be the principal external ſources of human diſeaſes; and climates are generally found favourable to health and longevity, in proportion as they are exempt from theſe natural cauſes of diſorder and decay.

It ought therefore to be inferred, a priori, that Ireland, celebrated for the ſingular equability of its temperature, and the ceaſeleſs motion of an atmoſphere always influenced by the moiſture of the Atlantic, ſhould be likewiſe characteriſtically free from natural diſeaſe; and experience proves that this concluſion is true.

The exhauſting agues of North America, or the fens of England †; the fatal fluxes which prevail in the low countries of the continent of Europe; the dreadful bilious diſtempers of both the Indies; the peſtilence which deſolates the African and Aſiatic climates; are all either entirely unknown, or but feebly felt in Ireland. There is here no characteriſtic diſeaſe to mark a natural ſource

* The latitude of Kamſchatka correſponds to that of Ireland; the weſterly winds are prevalent in each; yet the former experiences a rigorous winter of nine months, and the latter rarely of as many days. See Cook's Voyage in 1779, vol. iii. ch. 6.

† The ague is ſo rare, in ſeveral parts of Ireland, that many perſons are totally unacquainted with it. In the northern province the Author has never met with the diſeaſe, and its exiſtence there is generally denied.

ſource of unhealthfulneſs. There are few diſorders which cannot be directly traced up to ſome artificial cauſe; to ſome intemperance, to ſome neglect, to ſome exceſs, either of luxury or penury, in the ſuffering ſubject. Manufactures, in their kind, unwholeſome; induſtry exerted beyond its proper limits; irregularity in food or fermented liquors; illicit amours; colds, the conſequence of folly or inattention; exceſs or deficiency of proper exerciſe; anxiety and fretfulneſs of mind; together with the copious liſt of caſualties, afford to the phyſician of this country, the cauſes, and explanation, of almoſt all its diſorders.

From its peculiar ſalubrity the natives of this iſland are celebrated through Europe for juſt ſymmetry of proportion, and an athletic frame; becauſe, from earlieſt infancy to manhood, a check is rarely given to the progreſſive encreaſe of animal ſtrength, or the natural and appropriate forms of an undiſeaſed body. From the ſame Hygeian ſource flow thoſe ardent paſſions, thoſe exuberant ſtreams of animal ſpirits, which render our natives always chearful, oftentimes turbulent and boiſterous, the uſual conſequences of uninterrupted health and a vigorous conſtitution. Hence wild adventure, perſonal courage, impetuoſity of purſuit, inattention to conſequences, and improvidence of diſpoſition, become the characteriſtic features of minds, ſeldom under the influence of that anxiety, which, flying from the preſent moment and its enjoyments, watches for futurity, and pants after remote felicity.

The general temperature of our climate, in the vicinity of the capital, is ſomewhat lower than the 50th degree of Farenheit's thermometer*; and a mean of the hotteſt or coldeſt months of our year rarely varies more than 10 degrees from this ſtandard heat †. Winter therefore, with us, is uſually accompanied by a temperature of 40 degrees; ſpring and autumn of 50 degrees; and ſummer of 60 degrees of the thermometer: and the general heat of any ſingle month of theſe ſeveral ſeaſons ſeldom varies much from the correſponding temperature of that particular ſeaſon to which it belongs.

Of theſe limits, the loweſt is not ſufficiently cold to check the growth of any of the natural herbage of our iſland, nor the higheſt powerful enough to parch the ſurface of a moiſt ſoil, or to ſcorch its luxuriant graſſes. Hence it comes to paſs that our fields maintain a perpetual verdure, unimpaired by either ſolſtice. Hence too the farmer is enabled to lay his lands under graſs almoſt at any ſeaſon, even at the commencement of winter ‡: and hence the grazier never loſes the benefit of his rich paſtures at any period of the year, unleſs during the tranſient paſſage of a temporary drift of ſnow; ſo that horſes, cattle, and ſheep, arrive here, with

 little

* See Hamilton's Paper on the Temperature of Ireland, in the ſecond volume of theſe Tranſactions.

† See State of the weather in Dublin, from June 1791 to June 1793, by Mr. Kirwan, Vol. V. of the Tranſactions.

‡ See Young's Tour in Ireland, Vol. I. p. 130.

little care, at a degree of perfection unattainable in other countries without infinite expence and trouble.

For the growth of flax, the ſtaple commodity of the kingdom; of potatoes, the general food of its inhabitants; and of barley, from whence the ardent ſpirits, and other fermented liquors of the country are derived; the climate ſeems to poſſeſs a peculiar felicity of temperature and moiſture, in all its ſeaſons; and for their neceſſary degree of ripeneſs, the heat of ſummer is amply ſufficient.

It is for the more delicate ſpecies of garden fruits; for ill conducted crops of oats in bleak and mountainous ſituations; and for the complete and perfect maturity of wheat; that uneaſy apprehenſions can ever be entertained by the gardener or the farmer.

The former are, in themſelves, of little importance; and where ſuch luxuries are required, glaſs coverings, and artificial heat, afford an ample ſupply, and remove all pretence for diſcontent. Human art and induſtry, attentive to circumſtances, and accommodated to times, has ſtolen from the mild temperature of our winters as much warmth, as ſerves to compenſate for the deficiency of ſummer heats in forwarding and perfecting the crops of wheat; and a little time will teach the farmer, in our mountainous provinces, to uſe the ſame artifice with reſpect to his oats, whenever neceſſity ſhall demand his encreaſed attention.

To

To ſum up matters, then, with truth and brevity—A denſity of population, ſurpaſſing that of the vaunted millions of undepopulated France*; a copious export trade in proviſions of various kinds, unequalled by any kingdom whoſe inhabitants are proportionably numerous †; and a ſtaple manufacture unrivalled

 in

* The inhabitants of Ireland amount to more than four millions. (See Mr. Buſhe's Memoir, Iriſh Tranſ. Vol. III.)

Hence, the denſity of its population is at the rate of 182 perſons to a ſquare geographical mile, ſuppoſing the iſland to contain, in round numbers, 22000 ſuperficial miles.

Mr. Zimmerman, in his Political Survey of Europe, erroneouſly ſuppoſing the inhabitants of this country leſs than two millions and a half, deduces a denſity of population equal only to 117 perſons on each mile. The following table marks the number of individuals on a geographical ſquare mile in the northern countries of Europe, as taken from Zimmerman's tables (Ireland being corrected) from whence it will appear that this kingdom rates extremely high in the denſity of its population.

	Perſons.
Denmark	12
Sweden	14
Ruſſia	20
Scotland	51
Poland	53
Pruſſia	67
England	129
Germany	135
France	152
Ireland	182
Holland	236

† Two hundred and twenty thouſand barrels of beef and pork, independent of the various matters connected therewith, and of every other ſpecies of proviſions, were exported in the year ending 25th March 1793.

in general uſe, in certainty of produce, and intrinſic value *; are circumſtances which have not fallen to the lot of other nations, and bring with them clear and irrefragable evidence to demonſtrate a ſalubrious country, a genial climate, and a fertile ſoil in Ireland.

Concluſion.

In this Memoir I have endeavoured to prove from natural, and almoſt incontrovertible regiſters of the phænomena of later years, that the winds, and particularly the weſtern ſtorms, have ſwept with encreaſed violence over Ireland.

From this fact I have deduced a neceſſary change in its climate; a more general equability of temperature through the year; ſummers leſs warm, and winters more mild and open: and, laſtly, I have endeavoured to ſupport this concluſion by general obſervation, and the enumeration of particular inſtances where the defect of ſummer heat and winter ice ſeem to be moſt ſtrongly marked.

One queſtion ſtill remains, curious in its principle, and intereſting in its ſolution—Why have theſe weſtern ſtorms blown with unuſual and encreaſed violence?

The

* After a progreſſive encreaſe of ninety years, the exports of linen cloth alone, in the year 1792, amounted to forty-three millions of yards, from one million only at the commencement of the preſent century.

The limits of a Memoir, ſuch as this, do not permit me to enlarge on this ſubject, and even appear to include a reproof for the length of the preſent interruption. I ſhall, therefore, treſpaſs no longer on the moments of the Academy than to ſuggeſt a few queries, which may ſtand over for future conſideration; leaving it to time, and the ingenuity or better directed obſervations of others, to verify, to diſprove, or to contemn the hints which may be contained in them.

1ſt, Have not our winds become more violent, and the temperature of our ſeaſons more equable, ſince the foreſts of Ireland were cleared, and the country cultivated? and have not theſe winds, and that equability of temperature, been nearly proportioned to theſe, as to their cauſes?

2d, Have not ſimilar changes occurred under analogous circumſtances in North America; even in Canada, that country of extremes in heat and cold? And did not the iſland of Bermudas, though ſituated ſo much to the ſouthward of us, become barren of fruit, in conſequence of the deſtruction of its timber trees?

3d, Has it not appeared from obſervations on the aſcent of balloons, and the motion of clouds, that the lower maſs of air often purſues a different courſe from the upper ſtratum? May not then the limits of our ſtormy currents of air be often confined within a few hundred yards of the ſurface of the earth? and if ſo, is it not poſſible, and even probable, that the frequent interruption of

of foreſts and groves, and hedge-row trees, might have formerly very much retarded, and finally checked, the progreſs of a tempeſt?

4th, HAVE not all the countries of Europe, Aſia and America, within the parallel of Ireland, been very much denuded of their foreſts within the preſent century? and have not the encreaſed velocity of the weſterly winds been proportioned to this deſtruction of the foreſts and trees, as to their natural cauſes?

5th, Is it not probable, ſince the prevalent winds of our parallel have a weſterly tendency, that circumſtances which have removed impediments to their career round the entire globe, would give encreaſed velocity to their courſe?

6th, SHOULD not Ireland, launched as it is into the Atlantic, beyond the other coaſts of Europe; and denuded, as it has been, of foreſts and hedge-row trees, be the moſt ſenſibly affected by encreaſing tempeſts from the weſt, and the firſt to experience their influence on its climate?

WHETHER theſe queries have any foundation in nature, or are merely to be eſteemed the reſult of an unreſtrained imagination; whether ſo diminutive an animal as man, ſo temporary in duration, ſo impotent in ſtrength, acting through the lengthened period and perſevering efforts of a large portion of his ſpecies, can reaſonably be deemed equal to the involuntary production of ſuch

ſuch vaſt effects; to a change even of the elements and climates of the earth, may admit of doubt, of oppoſition, and even of denial. For theſe reaſons I have taken the liberty ſimply to propoſe them as matters of enquiry, and only beg the indulgence of the Academy for troubling them with matters that may not be attended with ſufficient evidence to bring conviction, or even to eſcape cenſure.

POSTSCRIPT.

October 20th, 1795.

The preſent year (1795) has been, comparatively, cold in its commencement, and warm in its ſummer; it has been calm, dry, and in many reſpects a contraſt to the long ſeries of preceding years whoſe effects are regiſtered in this Memoir.

Yet the extremes of its temperature have not been equal to thoſe of former years, as far as can be inferred from the recorded effects of heat and cold on natural objects. The large rivers of the northern province have not been bound firmly in the icy chains of winter; nor have grapes ripened in favourable aſpects in any part of the kingdom during ſummer, as formerly occurred, in ſeaſons whoſe temperature was denominated extreme.

HISTORY *of a* CASE *in which very* UNCOMMON WORMS *were diſcharged from the* STOMACH; *with* OBSERVATIONS *thereon.* By SAMUEL CRUMPE, *M. D. M. R. I. A.*

Read December 6th 1794.

THE lady whoſe caſe I am about to relate had been for many years ſubject to inflammatory affections of the lungs, which generally terminated in a copious and long continued expectoration. I was called to her aſſiſtance for the firſt time on the 2d of November 1788; ſhe was then about twenty-ſix years of age and had been about two years married. She appeared to me to labour under the ſymptoms which characterize the advanced ſtages of phthiſis pulmonalis, and which need not here be enumerated; and to theſe, according to her own account, ſhe had been more or leſs liable every winter and ſpring for ſome years back. As her ſweats were very profuſe, and ſhe complained much of troubleſome cough, and want of reſt, the principal remedies preſcribed were thoſe calculated to reſtrain the preſſing ſymptoms; and conſiſted chiefly of the weak vitriolic acid, and thebaic tincture. By theſe ſhe found herſelf relieved until the 22d of

December, when ſhe was ſeized with an evident peripneumony, attended by conſiderable pain under the ſternum, which required, and yielded to, copious blood-letting and bliſters. It terminated as uſual in an abundant expectoration, and ſhe recovered from it but ſlowly. About the latter end of February however ſhe began to gain ſtrength and ſoon after was to all appearance perfectly recovered.

On the 14th of July 1789 I was again called to her, and found her again labouring under the ſymptoms of pneumonic inflammation; from which ſhe was by the uſual mode of treatment freed in four or five days.

August 4th I was again called on. She has been troubled for five or ſix days paſt with a vomiting of blood, which generally recurs twice or thrice in the twenty-four hours; and is preceded by a ſenſe of weight and oppreſſion about the præcordia, which are relieved by the vomiting. The quantity thrown up is various at different times; ſometimes a tea-cup full, ſometimes not two table-ſpoon fulls, and generally in clots. Complaints alſo of want of ſleep, profuſe night ſweats, tendency to cough, which is prevented by great ſoreneſs in her cheſt, want of appetite, and ſometimes difficulty of breathing; pulſe natural in point of frequency, but very full, belly regular. She was bled to about eight ounces, blood remarkably ſizy.

August 6. Symptoms as before, excepting the pulſe, which is very natural. She was ordered an infuſion of the bark, with the vitriolic acid, and a mucilaginous opiate.

August 8. Has continued to take the infuſion regularly; vomiting of blood ſtill continues; ſleeps rather better; cough eaſy; ſweats continue. Let the infuſion be continued.

August 12. Took the infuſion regularly. Vomiting of blood continues; ſweats as before, cough eaſy, and expectoration free.

August 13. Has taken the infuſion regularly. Vomiting of blood has ceaſed; but ſhe is troubled with retchings and vomiting every morning, preceded by ſweats, and a gnawing ſenſation in the ſtomach. In vomiting this morning ſays ſhe threw up three ſmall worms, which have not been preſerved. Cough has diſappeared; ſweats decreaſing, except before the morning vomiting; ſleeps pretty well. Continue.

August 24. The vomiting has recurred at intervals without any worms having been thrown up, 'till this morning, when a conſiderable number of ſmall ones, and of an uncommon ſhape, were diſcharged. Sweats have almoſt entirely ceaſed, and ſhe is in other reſpects well. Continue the infuſion.

September 3. Was ſeized this morning with a return of vomiting, when ſhe threw up a conſiderable number of worms ſimilar to the laſt, and one of a much larger ſize and different ſhape, mixed with bloody and corrupted matter; the ſmall ones were ſo numerous they could not be reckoned, the entire matter thrown up being full of them. No cough, dyſpnœa, or other diſtreſſing ſymptom.

℞. Stanni pulverati drachmam, Salis Martis granum, fiant pulveres tales octo, & ſumat unum quater de die.—Repetatur Infuſum Corticis.

SEPTEMBER 5th. Has taken the whole of the powders; ſlight returns of vomiting; no appearance of worms; ſhe was ordered and took a vomit of Ipecacuanha-wine, which operated well, but neither worms or bloody matter were diſcharged. The infuſion was ordered to be continued.

SEPTEMBER 26th. Sweats have diſappeared; cough is but ſlight; the vomiting pretty frequently recurs, but is not preceded by any unuſual ſenſation, nor is it more frequent than in her former pregnancy. No appearance of blood or worms; ſtrength in general much improved.

She was ordered to omit all medicines, was ſafely delivered of her child at the uſual time, and is now in perfect health; though in general delicate, and ſubject to violent colds.

OBSERVATIONS.

THE worms thrown up are delineated of the natural ſize and appearance in fig. 1. and 2. Fig. 1. repreſents the large one, conſiſting of a head and twelve joints; the three firſt joints are furniſhed each with a pair of legs, which all the others want. Fig. 2. repreſents the ſmall worm, of which ſuch numbers were diſcharged; and fig. 3. the belly of the ſame, viewed through a good common magnifying-glaſs. It conſiſts of a head and ten joints, and has three double rows of legs; one double row on each ſide, and one double row of ſhorter ones down the middle of the belly. It has beſides three legs projecting in the form of a tail from the laſt joint.

ALL thoſe worms ſhewed ſigns of animation when diſcharged, eſpecially on being expoſed to the heat of the ſun, but ſoon died.

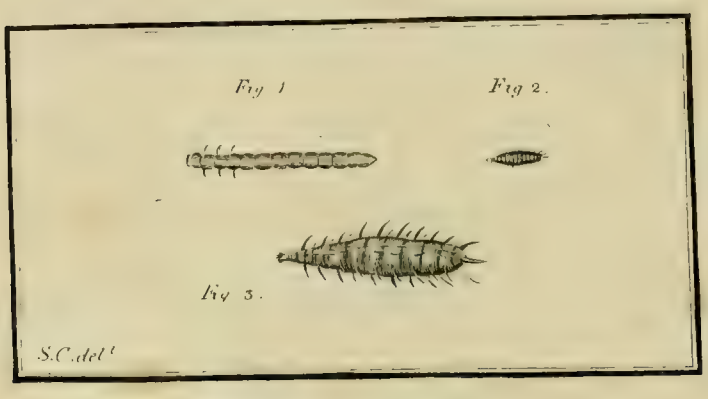


Fig 1
Fig 2.
Fig 3.
S.C. del.t

died. They appear to me to be the larvæ of ſome inſect, but of what particular ſpecies I am not naturaliſt minute enough to determine. The large one appears very ſimilar to the larva of the common beetle. We have many inſtances related by various authors, of different ſpecies of worms diſcharged from the inteſtinal canal; but of the different deſcriptions I have read, or ſpecimens I have ſeen preſerved in anatomical collections, none have ſtruck me as in any degree ſimilar to thoſe diſcharged by the patient whoſe caſe has been juſt related. It is probable, as has before been mentioned, that the worms diſcharged were the larvæ of ſome inſect which does not uſually depoſit its eggs in any part of the human frame; but which having been accidentally depoſited in, or conveyed into the body, were hatched, and acquired the ſize and form we have delineated.

That flies of various kinds depoſit their eggs in living animal bodies, and that theſe eggs are by the heat of the animal hatched and transformed into maggots, is evident from the inſtance of many ſo produced in the rectum of horſes, and backs of black cattle. The human body being in general better covered, and better defended from the attempts of ſuch inſects, does not exhibit ſo many inſtances of this nature. Still however it is liable to their attacks. Many caſes have been publiſhed of various inſects being hatched, and producing excruciating pain in the antrum maxillare, and other cavities leading to the noſe. Other worms, evidently the larvæ of external inſects, have been diſcovered in the inteſtines: And in the Medical Commentaries for the year 1787 there is a curious caſe of ſome exiſting under the ſkin.

A YOUNG lad of about twelve years of age was afflicted with excruciating pains in his limbs, to ſuch a degree as to render life miſerable. The pains were deemed rheumatic, and the uſual remedies for that diſorder applied without ſucceſs. At length ſome worms worked their way out of different parts of his body, particularly the knees, breaſt and forehead; and he was immediately after conſiderably relieved. The worms are deſcribed as near an inch long, all in joints on the back, and with hard ſcales on them. The attending phyſician aſcribes their origin to ſome flies having pierced the ſkin and lodged their ova in the punctures. Several other boys in the ſame part of the country were that ſeaſon affected in a ſimilar manner.

MANY inſtances have been given by medical authors, of inflammatory and other affections of the lungs occaſioned by worms, ſome of which proved fatal; ſome being relieved, or totally removed by the diſcharge of theſe animals. Morgagni in the 2d book of his incomparable work *De Cauſis & Sedibus Morborum*, gives us the caſe of a patient, who laboured under every ſymptom of pleuriſy, which terminated by his ſpitting up a quantity of blood with a round worm; after which he immediately got well. He in the ſame place quotes a work publiſhed by Ignatius Pedratti on the pleuriſy from worms.

WE have other inſtances of worms diſcharged from the lungs by coughing, in Schenkius *Obſerv. De Pulmonibus*, lib. 2, in Lieutuad *Hiſt. Anatom. med.* in Percival's Eſſays, and in the works of ſeveral other medical writers.

IT may perhaps be imagined that the pulmonic affections under which our patient laboured might have been owing to the

the worms ſhe diſcharged, which perhaps worked their way downwards from the lungs into the ſtomach; this however does not appear probable; her having been ſubject to them for a ſeries of years, their being frequently excited ſuddenly by the application of cold, and there terminating without the diſcharge of any ſuch animals, are circumſtances which militate ſtrongly againſt the idea.

THERE can however I believe be little doubt that the complaints of the ſtomach with which ſhe was ſeized, and the vomiting of blood, were occaſioned by their preſence; and that they formed for themſelves a nidus in the coats of the ſtomach appears pretty evident from the purulent and bloody matter which accompanied the diſcharge of the laſt portion of them.

NONE of the ſymptoms attending the vomiting of blood were ſuch as indicated the preſence of worms in the ſtomach and inteſtines; nor when their preſence was aſcertained did the vermifuge medicines given appear to accelerate the cure; ſtill however the caſe may be inſtructive; as proving that the hæmatemeſis or vomiting of blood ſometimes ariſes from this ſource, and therefore that the phyſician ſhould keep ſuch a cauſe of the diſorder in view whenever it proves obſtinate or dangerous; and the hiſtory is curious, as affording one certain fact reſpecting the nidification of inſects in the internal parts of the human frame.

LIMERICK, December 1, 1794.

P. S. I ſend the worms themſelves preſerved in ſpirits of wine to be depoſited in the collection of the Academy.

ESSAY *on the* BEST METHOD *of* ASCERTAINING *the* AREAS *of* COUNTRIES *of* CONSIDERABLE EXTENT.

By the Rev. JAMES WHITELAW, *Vicar of St. Catherine, Dublin, and M. R. I. A.*

Read April 25, 1795.

MODERN geographers, and particularly thoſe of Germany, have, of late years, cultivated a ſcience to which they have given the name of *Statiſtics*, the object of which is, to aſcertain the extent, population, denſity of population, military and naval force, revenues, national debt, &c. of the various ſtates of Europe. This ſcience, intereſting to every enlightened mind, and peculiarly ſo to the ſtateſman, is, as yet, in its infancy; and that particular branch of it, which enables us to determine the areas or ſuperficial contents of countries, has been hitherto ſo neglected, or conducted on ſuch erroneous principles, that the calculations of different authors are perfectly inconſiſtent with each other, and with truth. Some areas in our tables are, it muſt be acknowledged, ſufficiently accurate; but as truth and error are advanced with equal confidence, and equal authority, ſuch are uſeleſs to the reader, who, incompetent to make a ſelection, cannot proportion his aſſent to their merit.

The ſtrange inconſiſtencies that occur in ſtatiſtical tables will appear more ſurpriſing, when we conſider that the preſent cultivated ſtate of geography, though far from perfection, leaves little room for thoſe enormous errors which were formerly inevitable: When ſuch, therefore, occur in modern publications, we may juſtly, I think, impute them either to want of ſkill or want of care in the author; and conclude that his method was incorrect, or that he performed the operation on very erroneous maps. The following are a few of the numerous inconſiſtencies to which I allude, but ſufficient to ſhew the very imperfect ſtate of this part of the ſcience of ſtatiſtics.

Europe in ſquare Miles, of 60 *to a Degree, by various Authors.*

		Difference between each and Kitchin's map.
Kitchin's map of Europe, according to Zimmermann, - -	2,180,466—	
Buſching - - - -	2,432,000—251,534	
Statiſtiſche Ueberſicht or German political Tables 1786 - -	2,712,112—531,646	
Templeman's Survey of the Globe -	2,749,314—568,848	
Crome, on the Size and Population of Europe 1785 - - -	2,785,440—604,974	
Bergman's Natural Geography -	2,906,112—725,646	

Here the laſt difference is above four times the area of the kingdom of France.

Amidst

AMIDST errors of ſuch magnitude how can we diſcover truth? is an obvious queſtion. It has often employed my thoughts, and I take the liberty of ſubmitting the reſult to the Academy.

A *ſmall* portion of the earth's ſpherical ſurface may be accurately repreſented by a map drawn on a plain ſurface, and the menſuration of ſuch map, by the ordinary methods uſed by ſurveyors, will give the area of the country it repreſents, with ſufficient correctneſs: but in maps of extenſive regions the rule no longer holds, and the impoſſibility of juſtly delineating any conſiderable portion of a ſphere on a plain has induced geographers to have recourſe to the various methods of projection, ſuch as the ſtereographic, orthographic, &c. Maps conſtructed on ſuch principles may give the relative ſituation of places, with reſpect to bearing, meridians and parallels, but cannot convey any accurate idea of form or ſuperficial contents: they are, at beſt, but diſtorted reſemblances, and the greater the extent they embrace the greater the diſtortion, and the more incorrect the area: to ſuch maps a ſcale cannot be applied, and they are conſequently totally unfit for the purpoſe of menſuration.

THAT the area of even a ſingle kingdom of moderate dimenſions muſt differ very conſiderably from that of its map, will be evident from conſidering the different methods of conſtructing the latter.

THE uſual kinds of projection for particular maps are the ſtereographic on the plane of the horizon, the conical, and the circular.

IN the firſt, which is founded on the rules of perſpective, equal tracts of country are repreſented as very unequal, gradually encreaſing as they recede from the centre of the plane of projection; hence no common ſcale can be applied to the map, which is therefore totally unfit for menſuration.

THE conical projection is ſo called, as it is produced by the application of a cone to a ſphere, according to certain rules. In this the meridians are right lines on the cone, converging at its vertex, and perpendicular to the parallels of the lat. which are circles, deſcribed from the vertex as their common centre: The diſtance between the meridians is correct, only on the two parallels formed by the interſections of the ſphere and cone, between which they will approach too near, and every where elſe recede too far from each other; and hence the area of that part of the map delineated on the portion of the cone which falls within the ſphere will be leſs than the truth, while without thoſe limits it will proportionably exceed it. This is an ingenious and elegant projection, and as the conical area between its extreme meridians and parallels is perfectly equal to that portion of the ſphere it repreſents, if the limits of the country delineated on it perfectly coincided with thoſe lines, it would neceſſarily give the true area: But this never happens, and to ſpeak

ſpeak with mathematical accuracy it is liable to the ſame objection as the laſt, viz. that a ſcale cannot be applied to it; for countries, however, of moderate extent in latitude, it is the beſt that can be deviſed.

In the circular projection the parallels of lat. are circles, deſcribed from the pole as the common centre, with radii equal to the complements of their reſpective latitudes: the meridians preſerve their due diſtances on the parallels, becoming gradually curvilineal, and cutting the parallels more and more obliquely, as they recede from the central meridian; but as this alone can be a right line, and cut the parallels perpendicularly, it is obvious, that this projection muſt produce diſtortion in the map, and conſequently an error in its area, which, if it is greatly extended in longitude, will at length become enormous: for countries, however, of moderate dimenſions, it is one of the leaſt objectionable projections, and a ſcale may be adapted to it with ſufficient accuracy, though not with geometrical preciſion.

There is another method of projection, uſed by the Sanſons, in which the parallels are right lines, and the meridians, which obſerve their due diſtances on the parallels, are parabolic curves. This is admiſſible only in delineating countries of inconſiderable extent in longitude, and Mr. D'Anville has preferred it for his map of South America: In all other caſes it produces much greater diſtortion than any of the above methods.

In

In the cylindrical projection the countries on each ſide of the equator are conceived to be delineated on the ſurface of a cylinder, cutting the ſphere in two parallels, nearly midway between the equator and the top and bottom of the map: The meridians and parallels are right-lines, cutting each other at right-angles, and the former obſerve their due diſtance only on the interſections of the cylinder and ſphere: This projection is evidently the beſt for the tropical regions; but, as it is not of general application, and partakes of the perfections and imperfections of the conical, it is ſufficient to have mentioned it.

Although it is thus evident that the area, reſulting from the ſimple menſuration of every ſpecies of map, however projected, muſt, (except the country repreſented be of ſmall extent) differ conſiderably from the true area, yet there is reaſon, I think, to ſuſpect that the generality of ſtatiſtical writers have only performed the operation in the uſual way, and perhaps on maps injudiciouſly ſelected, without taking any precaution to correct the errors which muſt inevitably ariſe from ſuch a proceſs; at leaſt the ſtrange inconſiſtency obſervable in their tables, with their want of candour, in not communicating to the public their method and materials, ſubject them to this ſuſpicion. A few, indeed, have given us ſome numbers ſufficiently correct, but by what means they diſcovered truth, as they are ſilent on the ſubject, we are ignorant. I ſhall, therefore, make no apology for offering the following method of nearly determining the true areas of maps: It is, I believe, new, and will be found, I hope, ſufficiently

ſufficiently accurate for the purpoſes for which ſtatiſtical tables are intended; for minute preciſion is impoſſible, and if poſſible would be unneceſſary.

Method of nearly determining the true Areas of Maps on the Conical and Circular Projections.

Parallels of latitude, diſtant from each other one degree, will divide the ſpherical ſurface of the earth into 180 narrow zones; the area of each of theſe, in ſquare miles of 60 to a degree, is found by multiplying its ſine in miles and decimals of a mile by 21600, the circumference of a great circle in ſuch miles; and the area of each zone, thus found, divided by 360, will give the area of each of the quadrilateral ſpaces, formed by the parallels, which include the zone and two meridians diſtant one degree of longitude from each other: On this principle the following table was conſtructed.

Lat. of the Zones.	Area of Quadrilat.	Lat. of Zones.	Area of Quadrilat.	Lat. of Zones.	Area of Quad.	Lat. of Zones.	Area of Quad.	Lat. of Zones.	Area of Quad.
Between 0 and 1°	3594 . 8	15—16	3462 . 0	30—31	3097 . 5	45—46	2519 . 7	62—63	1660 . 0
1 2	3593 . 7	16—17	3446 . 2	31—32	3065 . 1	46—47	2474 . 6	63—64	1604 . 0
2 3	3591 . 5	17—18	3429 . 2	32—33	3031 . 9	47—48	2428 . 6	64—65	1547 . 7
3 4	3588 . 2	18—19	3410 . 4	33—34	2997 . 8	48—49	2382 . 1	65—66	1490 . 7
4 5	3583 . 8	19—20	3390 . 0	34—35	2962 . 6	49—50	2334 . 7	66—67	1433 . 4
5 6	3578 . 4	20—21	3367 . 3	35—36	2926 . 7	50—51	2286 . 8	67—68	1375 . 5
6 7	3571 . 8	21—22	3344 . 8	36—37	2889 . 8	51—52	2237 . 8	68—69	1317 . 5
7 8	3564 . 2	22—23	3321 . 3	37—38	2852 . 1	52—53	2188 . 4	69—70	1259 . 0
8 9	3555 . 5	23—24	3296 . 7	38—39	2813 . 4	53—54	2138 . 2	70—71	1201 . 2
9 10	3545 . 6	24—25	3271 . 3	39—40	2773 . 9	54—55	2087 . 6	71—72	1141 . 8
10 11	3534 . 8	25—26	3244 . 7	40—41	2733 . 6	55—56	2036 . 1		
11 12	3522 . 8	26—27	3217 . 3	41—42	2692 . 4	56—57	1984 . 2		
12 13	3509 . 7	27—28	3188 . 6	42—43	2650 . 5	57—58	1931 . 5		
13 14	3495 . 6	28—29	3159 . 3	43—44	2607 . 6	58—59	1878 . 3		
14 15	3480 . 4	29—30	3128 . 8	44—45	2564 . 1	59—60	1824 . 6		
						60—61	1770 . 2		
						61—62	1715 . 4		

To

To render the application of the above table and ſubſequent proceſs more intelligible, I have annexed a ſketch of the projection and outline of the map of Germany.

HAVNIG drawn the contour of the country with all poſſible accuracy, and expreſſed it by a very fine line, obſerve what quadrilateral ſpaces lie entirely within it; encloſe theſe by a ſtrong black line, and the area of all within it we may call the *integral area*, as it conſiſts of entire quadrilaterals; and that without it, the *fractional area*, as it is compoſed of parts of quadrilaterals.

THE *integral area* may be found with the greateſt accuracy thus: I find, in the table, that a quadrilateral between the 53d and 54th parallel contains 2138.2 ſquare miles, and that there are ſix ſuch in the *integral area*; therefore $2138.2 \times 6 = 12829.2$ will give the true contents of that portion of it which lies between theſe parallels, and a ſimilar operation for the zones between the other parallels will give 144023.6 as the entire *integral area* of Germany.

THUS far (ſuppoſing the map correct) there is no poſſibility of error. The contents of the fractional area can be found only by approximation: The method I propoſe is this:

LET it be required to find the area of the ſpace A in the quadrilateral a b c d: having conſtructed a ſcale, from the extent of a degree of latitude, reduce the irregular waving contour *a b c* *Fig.* 1.

into a rectilineal outline, by ſhort balance, or (as they are vulgarly called) give and take lines, drawn by the aſſiſtance of a tranſparent ruler, with a thin fiducial edge: The polygonal ſpace A muſt then be reduced to a triangle by an operation familiar to ſurveyors, and its area found, by the uſual mode of multiplying half its altitude into its baſe: By a ſimilar proceſs, find the area of the polygonal ſpace B, which added to that of A, will give the area of the quadrilateral; and if this nearly coincides with the ſum, which reſults from multiplying its mean extent in longitude by 60, there has been no material error in the operation: The ſum of the areas thus found will be frequently very different from the true area of the quadrilateral, ſhewn by the table, and the error muſt be corrected by dividing the difference between the true and meaſured areas proportionally between the ſpaces A and B, thus,

Let the quadrilateral a b c d be ſituate between the 50th and 51ſt parallels of latitude, and its true area of courſe 2287 ſquare miles: But, in conſequence of the inevitable deviation from truth, in the projection of the map, this area produces by menſuration only 2247 ſquare miles; the ſpace A 1032, and the ſpace B 1215: To find the true areas of A and B,

as 2247 the meaſured area of the quadrilateral.
: 1032 the meaſured area of A.
:: 2287 the true area of the quadrilateral.
: 1050 the true area of A.

as

as 2247 the meaſured area of the quadrilateral.
: 1215 the meaſured area of B.
:: 2287 the true area of the quadrilateral.
: 1237 the true area of B.

When the true extent of the portions into which the contour line divides the quadrilaterals is thus adjuſted, the addition of the ſeveral numbers in the *fractional area* to the *integral* will give the contents of the map: and to prevent any confuſion in the numbers to be added, it will be adviſeable to ſtain the *fractional area* one uniform colour, and to add the numbers in the different zones in ſeparate columns.

By the above rules I meaſured the annexed map of Germany, including the Auſtrian Netherlands, taken from Mr. D'Anville: The following table ſhews the reſult and its relative proportion to the areas of different authors.

		Difference between each and D'Anville's map.
Mr. D'Anville's map taken from his firſt part of Europe, 1754 -	192552	
Templeman's Survey of the Globe -	156950—35602	—
Buſching, 1780 - -	177984—14568	—
(Statiſtiche Ueberſicht) in German, 1786 - - - -	192000— 552	—
Crome on the Size and Population of Europe, 1785 - - -	204736—12184+	

If the above method of finding the *fractional area* is not thought ſufficiently correct, I would propoſe the following, more laborious, indeed, but, if properly executed, more accurate.

A Quadrilateral, not exceeding one degree in extent, when accurately drawn on a plane ſurface, will produce an area by careful menſuration differing about 1. 3 ſquare miles in 1000 from its true extent on the ſphere; this error therefore being immaterial, delineate each quadrilateral in the fractional area on a ſeparate paper, and having drawn the contour line through it with great care and accuracy, meaſure each part as directed above, and if the ſum of the areas reſulting from this operation nearly equal that in the table, the operation may be conſidered as free from material errors; the ſmall difference that ariſes muſt be proportionally divided between the parts of the quadrilateral, that the whole and parts may be perfectly conſiſtent, and the numbers thus corrected written in their proper ſpaces in the map.

Area

Area of Germany and Switzerland, according to the Map of Mr. D'Anville, measured by the foregoing Method.

GERMANY.

	Fractional Areas.
Between the Parallels 45 and 46	530 . 0
	112 . 0
	80 . 0
	390 . 0
	1242 . 0
	380 . 0
	2734 . 0
46—47	127 . 0
	2279 . 6
	1672 . 6
	1094 . 0
	2236 . 6
	1792 . 6
	30 . 0
	9232 . 4
47—48	581 . 0
	658 . 0
	1738 . 6
	380 . 0
	6 . 0
	3363 . 6
48—49	960 . 0
	2198 . 1
	580 . 0
	10 . 0
	3748 . 1
49—50	5 . 0
	30 . 0
	230 . 0
	1050 . 0
	1105 . 0
	20 . 0
	2044 . 7
	1480 . 7
	25 . 0
	5990 . 4

	Fractional Areas.
50—51	400 . 0
	1443 . 8
	1872 . 8
	23 . 0
	3739 . 6
51—52	400 . 0
	570 . 0
	1007 . 0
	1129 . 8
	1426 . 8
	961 . 0
	65 . 0
	5559 . 6
52—53	825 . 0
	1082 . 0
	1907 . 0
53—54	270 . 0
	1338 . 2
	1928 . 2
	2014 . 2
	640 . 0
	20 . 0
	6210 . 6
54—55	275 . 0
	848 . 0
	896 . 0
	63 . 0
	41 . 0
	130 . 0
	824 . 0
	520 . 0
	30 . 0
	270 . 0
	867 . 0
	907 . 6
	Fermeren I. 50 . 0
	12 . 0
	Rugen I. 310 . 0
	6043 . 6

GERMANY.

Between 45 and 46 - -	2734 . 0
46 — 47 - -	9232 . 4
47 — 48 - -	3363 . 6
48 — 49 - -	3748 . 1
49 — 50 - -	5990 . 4
50 — 51 - -	3739 . 6
51 — 52 - -	5559 . 6
52 — 53 - -	1907 . 0
53 — 54 - -	6210 . 6
54 — 55 - -	6043 . 6
Total *fractional area* -	48528 . 9
Total *integral area* -	144023 . 6
Total area of Germany -	192552 . 5

Germany, in the above area, comprehends the Auſtrian Netherlands, Dutch Limburg, Pruſſian Guelders, that part of Iſtria ſubject to the Houſe of Auſtria, and the territory of Aquileia.

SWITZERLAND.

Between 45 and 46 -	85
	245
	105
46 — 47 -	73
	1594 . 6
	2384 . 6
	2289 . 6
	1947 . 6
	15 . 0
	70 . 0
47 — 48 -	460
	1497 . 6
	1770 . 6
	690 . 0
Total area of Switzerland -	13227 . 6

Switzerland, in the above are, comprehends the Swiſs-cantons, their allies, their ſubjects, and the ſubjects of their allies.

THREE SCHEMES *for* CONVEYING INTELLIGENCE *to* GREAT DISTANCES *by* SIGNALS. *By* JOHN COOKE, *Eſq; M. R. I. A.*

Read Dec. 6, 1794.

THE great expedition with which the French Telegraph tranſmits diſpatches has excited a conſiderable degree of public attention; its uſe in war is manifeſt, and 'tis probable that it may be applied to commercial purpoſes with equal ſucceſs. While the knowledge of this invention remains confined to any nation it muſt be attended with advantages inconſiſtent with the intereſts of other countries, and therefore an attempt to diſcover the principles of it, or to ſupply new methods of effecting the ſame end, is capable of conſequences beyond the mere gratification of curioſity.

THE firſt ſtep neceſſary in the following plans is to expreſs words by the ſmalleſt poſſible number of characters; for this purpoſe let the correſpondents be furniſhed with ſimilar alphabetical

betical vocabularies of our language, omitting ſynonymous terms, and ſuch as are not abſolutely neceſſary; they ſhould contain the proper names of men that generally occur, the names of contiguous and important places, and an appendix of ſuch phraſes and ſentences as the correſpondents may expect to have occaſion for; to the words of theſe vocabularies are to be annexed in marginal columns the ſingle letters, and the different combinations which ariſe by joining any two, or any three letters of the alphabet together, ſo that every word and ſentence in the vocabulary may have a ſign to repreſent it, conſiſting of one, two or three letters at the moſt; the variety of combinations thus produced by twenty-four letters (each combination conſiſting of two or three letters only) far exceeds the number of uſeful words, and affords ſigns ſufficient for a very copious addition of ſentences.

When intelligence is to be conveyed, the liſt of ſentences annexed to the vocabulary ſhould be examined for one adapted to the occaſion, and if any of them apply, the ſymbolical letters annexed thereto will denote it; but if there be no ſuch ſentence in the collection, the matter is to be put into the feweſt words which perſpicuity will allow, and the ſymbols which repreſent theſe words are to be ſubſtituted for them; thus the ſentence may be expreſſed by a ſet of letters which ſeldom amount to half the number neceſſary to ſpell the words of it. When proper

proper names occur which are not found in the vocabulary, or which cannot be formed out of any words in it, they muſt be expreſſed by their conſtituent letters, and admit of no abridgement. If ſecrecy be required, any preconcerted alteration of the arrangement of the words in the vocabulary will render the ſigns unintelligible to all except theſe who may be in poſſeſſion of the key.

After a ſentence ſhall be reduced into ſymbols or ſigns, the next conſideration is to convey them expeditiouſly to a great diſtance by a ſimple and certain method. Light ſeems to be the moſt proper inſtrument for this purpoſe, and may be applied in the following manner:

Let the ſpace through which the intelligence is to be tranſmitted be divided into ſtations, and at each of them let three lights be placed at conſiderable diſtances from each other, ſo as to be diſtinguiſhable from the two next poſts or ſtations: let there be a method provided of obſcuring any of them at pleaſure.

At each ſtation there is to be a perſon appointed to look out for ſignals at a certain hour; the ſignal requiring attention may be the exhibition of the three lights, and the ſame may be alſo the ſignal of readineſs to receive the communication: theſe three lights are intended to repreſent the three places of the ſymbolical letters

letters of the vocabulary, and their obſcurations denote the letters which occupy theſe places; thus one obſcuration ſignifies *A*, two *B*, three *C*, &c.

Suppose it were required to communicate the word "victory," the three lights are to be exhibited from the firſt ſtation; and when the ſame appearance is ſeen from the next ſtation, the vocabulary is to be ſearched for the ſign of that word, which we will ſuppoſe to be *K B A;* then the firſt light is to be obſcured ten times, the ſecond light twice, the third once, and then all may be concealed together to ſhow that the word is complete. Theſe ſignals ſhould be obſerved by two perſons at leaſt from the next ſtation, and if the reſult of their obſervations ſhould vary and occaſion doubt, the ſecond ſtation may exhibit two lights only, which ſignal requires a repetition of the laſt word; but if there be no diſagreement among the obſervers, the ſecond ſtation proceeds to tranſmit the ſame ſignals which it received to the third ſtation; and in the ſame manner they are communicated through all the intermediate poſts, until they arrive at the end of the line, where the obſerver examines the ſigns or ſymbols in his vocabulary for the letters *K B A*, (which may be eaſily found if arranged in alphabetical order) and there finds the word "victory" annexed to it. When the communications are to be forwarded by day, flags or any other object viſible by day may be uſed, and their elevations and depreſſions may be ſubſtituted

Fig. 2.

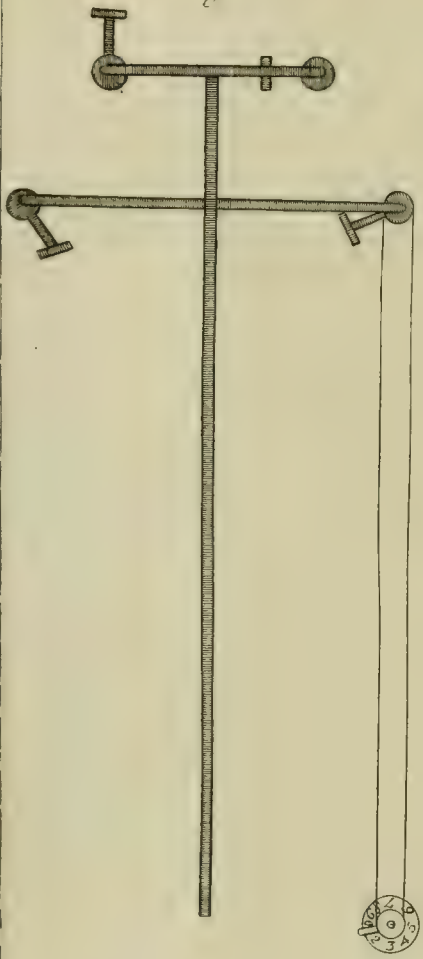


Fig. 3

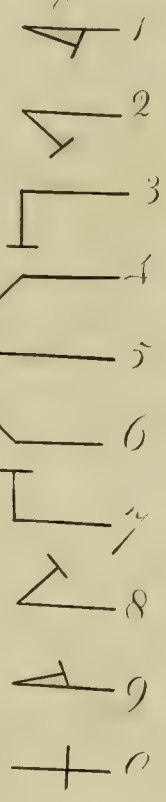
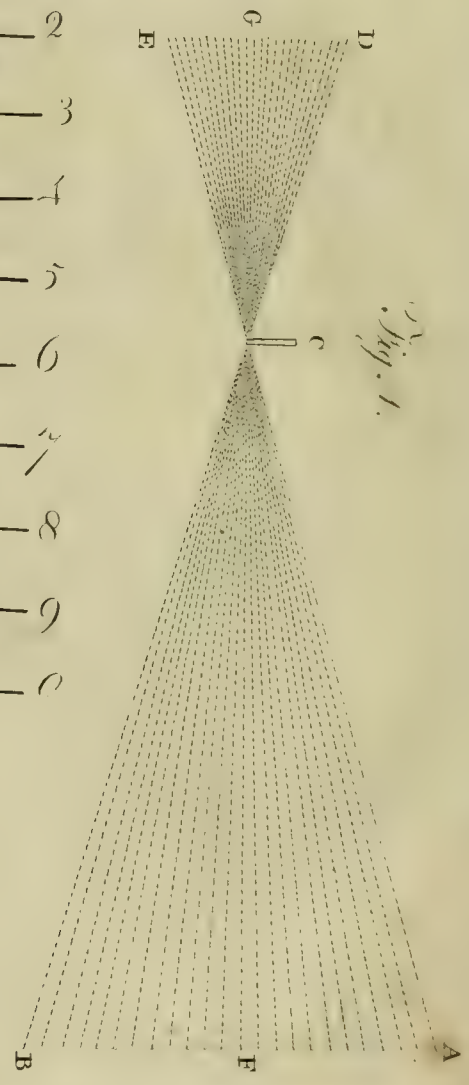


Fig. 1.



ſubſtituted for the exhibitions and occultations of the lights; even a ſingle light or flag may be made to anſwer the purpoſe, if any contrivance be annexed to ſignify to the obſerver when the occultations which denote a letter are ended, and alſo when a word is finiſhed.

Another method of transferring theſe ſignals is by altering the ſituations of theſe lights or flags, the plan of which will be better underſtood by a diagram than by any general deſcription.

The point *F*. fig. 1. repreſents the place from which the intelligence is to be ſent, and the point *G* that to which it is to be conveyed. In the horizontal line *A B*, 24 points are aſſumed at equal intervals to repreſent the letters of the alphabet, and marked as in the figure. When it is intended to ſignify a ſentence or a word, lights by night, or flags by day, are to be ſet up in the points of the line which repreſent the ſymbolical letters that denote it, and the true poſition of theſe lights or flags may be thus aſcertained at the point *G*. Let there be a pole erected at a convenient diſtance from *G* in the line *G F*, as at *C*, and a line *D E* parallel to *A B* be graduated as *A B*, and marked as in the figure with the 24 letters, the obſerver at *G* moves his eye along the line *D E* until the edge of the pole *C* is ſeen in the ſame line with the light exhibited in the line *A B* and the poſition of his eye in the line *D E* marks the letter

ſignified by the ſignal in the line AB: and thus by three lights by night, or three flags by day, may the ſymbolical characters of a word or ſentence be communicated. However it muſt be obſerved, that though the letters be thus repreſented, their places as they are written in the ſymbol do not appear, therefore it will be neceſſary that after the ſignals ſhall have been ſufficiently obſerved, they ſhould be removed in the order in which they are to be written, ſo that the ſignal which repreſents the letter at the left hand in the ſymbol ſhould be firſt removed, that of the middle letter is next to be removed, and the ſignal of the right hand letter is to be removed laſt: or their order may be denoted by the ſhape or colour of the flags or lights. Since the triangles ABC, CDE are ſimilar, the ſides $AC : AB :: EC : ED$. whence it follows, that if the diſtance AC be ten miles, the line AB 240 yards, and the diſtance EC a quarter of a mile, that the line DE will be ſix yards, and the graduations on it nine inches aſunder, a ſpace ſufficient to prevent confuſion or miſtake in aſcertaining the place of the ſignals fixed in the line AB, or if at the point where the obſerver is placed, a teleſcope be fixed, with a micrometer annexed, it will be poſſible to aſcertain the places of the ſignals with a great degree of nicety, and two lights in that caſe will be ſufficient to deſignate a word or ſentence.

In order to effect this an alteration muſt be made in the vocabulary, by changing the ſymbols of the words, from letters to

to numbers, beginning with unity and proceeding in regular order to the extent required, which 'tis ſuppoſed will not exceed ten thouſand. Then if the line in which the ſignals are to be placed be 255 yards 7 inches long, it may by divided into one hundred parts of 7 feet 8 inches each, the extremities of which parts ſhould be numbered, and if there be two lights or two flags diſtinguiſhable by their ſhape, or by their colour, or by both, one may repreſent units, and the other hundreds, by which any number under ten thouſand, and of courſe any word or ſentence in the vocabulary can be expreſſed: for inſtance, if the number of the word to be communicated be 5796, the flag or light which repreſents hundreds is to be placed in the graduation of the line of ſignals marked 57, which ſignifies fifty-ſeven hundred, and the ſignal which repreſents units is to be placed in the graduation marked 96, which denotes the number ninety-ſix, the ſum of which is the ſymbolical number propoſed.

In order to obſerve theſe ſignals and their places, Mr. Cavallo's inſtrument (deſcribed in the Philoſophical Tranſactions of the year 1791) ſeems to be well adapted; it is a micrometer of a very ſimple kind, applied to a three feet achromatic teleſcope, which magnifies about eighty four times, and with which he could meaſure an angle of 7 ſeconds accurately; the ſcale of it may be ſo marked that the numbers repreſented by the ſignals may be ſeen at the time of obſervation without calculation or moving any of its parts.

Mr. Cavallo ſhows in the ſame paper that an angle of one minute includes a chord of ſix feet at 20626 feet diſtance; whence it follows from the nature of ſimilar triangles, that at the diſtance of 52800 feet or ten miles, the chord of the ſame angle will be $15\frac{1}{3}$ feet nearly, and 7 feet 8 inches, the length of the diviſions of the ſignal line, will be ſeen under an angle of half a minute nearly, at ten miles diſtance, which may be taken with great certainty, ſince the inſtrument is capable of meaſuring a fourth part of this angle; another cauſe which muſt contribute materially to the exactitude of the obſervation is, that both the teleſcope and micrometer are to remain permanently fixed, as well in their direction as in the relative poſition of all their parts, and if the ſcale of the micrometer be graduated by the ſignals of the next ſtation, nothing but ſome diſturbance of the machinery can occaſion error, ſince the ſame immoveable mark on the ſcale is always referred to the ſame immoveable object.

It is evident, from the preceding method, that any ſort of ſignals capable of communicating all the numbers under ten thouſand will enable the correſpondents to denote words and ſentences thereby, and it ſeems poſſible to accompliſh this by an inſtrument ſomething like what we conceive the telegraph to be, as repreſented in the drawing, fig. 2. It is an upright pole with two immoveable tranſverſe arms, CD and EF, at the extremities

mities of which are placed hands capable of being moved round on their extremities by pullies and ropes; each of theſe hands is capable of ten different poſitions, which are ſufficiently diſtinguiſhable from each other, as may be ſeen in fig. 3, and which may repreſent the ten cyphers, and if we ſuppoſe the hand at *E* to repreſent units, that at *C* to repreſent tens, that at *D* to repreſent hundreds, and that at *F* thouſands, it is plain that the number of any word under ten thouſand may be denoted, by a ſingle arrangement of the parts of the inſtrument, and that theſe may be obſerved at a great diſtance by a teleſcope: for inſtance, if it were required to repreſent the number 2701, the hand at *F* is to be put into the ſecond poſition, that at *D* into the ſeventh, *C* into the tenth, and *E* into the firſt poſition. If it were neceſſary to repreſent a word the number of which was 26, the hands at *F* and at *D* are to be put into the tenth poſition, to ſignify no thouſands no hundreds, that at *C* into the ſecond, and that at *E* into the ſixth poſition. In order to work this inſtrument, there may be a pulley affixed to the end of each hand, and a rope, the ends of which are to be joined together, is to paſs over it, and alſo to paſs over another pulley of equal diameter at the bottom, ſo that the hand may be moved by moving the pulley below; let the lower pulley be furniſhed with an index, and let the numbers, which it may be required to repreſent by the hand above, be written on a fixed circle round the lower pulley ſo that the index may be turned to any of them, and faſtened there;

there; then the hand may be brought into the poſition required, by placing the index below on the number to be repreſented; and thus any perſon, though not acquainted with the ſignals, can work the machine without danger of error, and ſignify the numbers with almoſt as much diſpatch as they could be written. The form of one of theſe pullies with the ropes for working the hand is ſeen in the drawing at *A*, and the three remaining hands are underſtood to be furniſhed with ſimilar machinery.

It may be uſeful to obſerve that it is not neceſſary that the correſpondents ſhould underſtand any common language, for if they be furniſhed with vocabularies in their own reſpective tongues, and if the ſame ſymbols be referred in each to a word of equal import, every correſpondent will underſtand it through the medium of his own tongue, and the ſymbols will anſwer the purpoſe of an univerſal language for theſe, and alſo for other communications.

OBSERVATIONS *on the* POWER *of* PAINTING *to expreſs* MIXED PASSIONS. *By the Rev.* MICHAEL KEARNEY, *D. D. M. R. I. A.*

Read Nov. 14, 1795.

THE diſcourſes of the late Preſident of the Royal Academy of Painting, &c. not only diſplay a profound knowledge of profeſſional theory, but alſo contain many general tranſcendental principles of all the finer arts. The ſtudent of poetry or eloquence may derive from them almoſt equal inſtruction with the painter. It is therefore with the greateſt heſitation I venture to examine the juſtneſs of a deciſion made by ſo philoſophical an obſerver of human nature.

IN the diſcourſe delivered December 10, 1772, he cautions the young artiſt againſt aiming at the union of contradictory excellences, which muſt neceſſarily be mutually excluſive of each other. He then cenſures ſome perſons *who have been fond of deſcribing the expreſſion of mixt paſſions*, which they fancied to exiſt in ſome favourite work. Such expreſſion he pronounces to be

be out of the reach of art, and only aſcribed to ſuch works by perſons *who, not being of the profeſſion, know not what can or cannot be done.*

What Sir Joſhua Reynolds declares to be beyond the reach of art it is indeed hardineſs not to admit as impracticable; yet as the queſtion does not turn on the technical ſkill of a painter ſo much as on the powers of the human countenance, it may not be improper to diſcuſs it.

If this opinion were admitted in its ſtricteſt ſenſe, the painter muſt be pronounced incapable of exhibiting any but the merely elemental emotions, as moſt of the paſſions that affect the mind in the complicated tranſactions of human life are in a certain degree of a mixed nature. This however is unqeſtionably not the meaning of our author. It appears from the tenour of his argument that many affections in which a philoſophical analyſis diſcovers a compoſition were conſidered by him as ſimple, and that he confines his obſervation to ſuch paſſions as are in a popular ſenſe called mixed.

I must firſt take notice, that the examples of falſe judgment drawn by the Preſident from Pliny, relate to fixed, habitual, characteriſtical qualities, not to paſſions occaſionally exerted.

Yet without recurring to the powers ſuppoſed to be inherent in the human face by a modern fanciful phyſiognomiſt, may not the

the habitual temper, and even the blended ingredients that form it, be diſcerned often in the aſpect? Pliny deſcribes the ſtatue of Paris by Euphranor, which repreſents him as judex dearum, amator Helenæ, & interfector Achillis. This inſtance from ſculpture is cenſured by the Preſident; and yet why may not a dignified form and an expreſſed character of martial gallantry be united with the marks of an amorous temperament?

The characteriſtical portrait of the Demos Athenienſis, mentioned by Pliny, and ſaid to be allegorically painted by Parrhaſius, is indeed a moral monſter, formed of qualities utterly incompatible. Volebat namque varium, iracundum, injuſtum, inconſtantem; eundem exorabilem, clementem, miſericordem, excelſum, glorioſum, humilem, ferocem, fugacemque & omnia pariter oſtendere. Such a picture is beyond the reach of art; and it is as impracticable for painting to delineate ſuch an aſſemblage of contradictions as for the imagination to embody the mutually excluſive qualities brought together in Lock's deſcription of the abſtract idea of a triangle; or for the ſoul of Cardan to have cemented into one maſs the warring vitious paſſions with which, in the viſions of his diſtempered fancy, he ſeemed polluted.

But to come near to the queſtion: Can it be doubted that every indication of inward emotion which the countenance is capable of aſſuming the pencil of the painter may imitate on the canvas? If the original diſplays a ſenſible conflict of paſſions why muſt the power of the imitative art be limited to an *indiſtinct and imperfect marking?*

If then the above maxim be incontrovertible, as I think it is, we have only to enquire whether in fact the countenance ever expreſſes a mixture of emotions? While the ſoul is affected by any paſſion, if it be aſſailed by another of a different or diſcordant nature, the former will either give way or contend for predominance. In the firſt caſe there will be a moment of fluctuation, during which the expreſſion will be uncertain; that of the former not being totally effaced, nor the other yet excluſively aſcendant. Thus the lover in Lucretius viewing his miſtreſs *in vultu videt veſtigia riſûs*. This tranſient interval reſembles thoſe points of time ſo happily ſeized by Ovid in the Metamorphoſes before the entire receſs of the firſt form or conſummation of the new one. Though the painter's art, confined to a ſingle inſtant, could not delineate the rapid train of paſſions, *which dimm'd the face* of Satan on the view of Eden, and *thrice chang'd with pale ire, envy and deſpair*, yet were he even to ſelect the moment, *when his griev'd look he fixed ſad*, ſtill it muſt be Satanic ſadneſs, tinged with *deep malice and revenge*. I could almoſt conceive, that as the ſculptor in the ſtation of a ſtatue can imply its being in actual motion, ſo the magick of the painter can ſuggeſt to us how tranſient the emotion expreſſed is intended to be.—If the firſt impreſſed paſſion be firm enough to contend for ſuperiority with that ſuperinduced, does not experience prove that the features wear a form very different from that which either paſſion ſingle would produce? Does not the expreſſion participate of the character of each? Is there no difference, but in degree, between the aſpect of a man oppreſſed

oppreſſed by fear, and of one diſturbed by complexional timidity, yet ſupported againſt its influence by rational ſelf-diſcipline? The countenance of Coriolanus during the ſupplication of his mother and wife muſt have paſſed through a ſeries of expreſſions from that of an aſſumed cold ſtatelineſs, with which he covered his feelings, till when overpowered by natural affection *his eyes did ſweat compaſſion*. Through the whole of this conflict at no time did his countenance indicate an unmixed emotion, and even at the concluding triumph of filial duty, the great interpreter of nature hath repreſented him diſtracted almoſt to agony:

> Oh, my mother, mother! oh!
> You have won a happy victory to Rome:
> But for your ſon——*Believe* it, oh, *believe* it—
> Moſt dangerouſly with him you have prevail'd,
> If not moſt mortal to him. But let it come.

Andromache δακρυόεν γελασάσα (6 Iliad, 484) readily occurs as a beautiful illuſtration of the power of the countenance to expreſs blended feelings; it does not however appear to me to come ſo near the eſſence of the queſtion as to be competent to ſupport the deciſion of it. A variety of ſoft images ruſhed at once on the mind of Andromache; her heart was melted with a recollection of the many tender circumſtances that form the aggregate of domeſtic happineſs; and Hector's perilous ſtation excited a fear of loſing him who ſupported this happineſs; the little incident of infant terror quickened this maſs of tenderneſs; yet theſe emotions, being of a kindred nature, eaſily coaleſce into

one united charity. We have here a combination of concurring, not the perplexity of contending paſſions. Mingled tears and ſmiles are often marks of the affectionate feeling, though on moſt occaſions they denote contrary paſſions. A more applicable inſtance may be found in the Odyſſy, (19 Odyſ. 471.) where the great poet deſcribes, with exquiſite force and truth of colouring, the effect which the ſudden recognition of her old maſter produced in his nurſe Eurycleia.

Τὴν δ' ἄμα χάρμα καὶ ἄλγος ἕλε φρένα. τὼ δέ οἱ ὄσσε
Δακρυόφιν πλῆθεν. θαλερὴ δέ οἱ εσχετο φωνη.

The celebrated picture by Timomachus, in which Medea is repreſented meditating the murder of her children, has often with propriety been quoted as exhibiting a ſituation in which a conflict of paſſions muſt have ariſen:

Ira ſubeſt lachrymis; miſeratio nec caret irâ.

And it may be here obſerved, that this expreſſion of rage, controuled by ſofter feelings, muſt be more impreſſive and affecting than that of the frenzy which would diſtort the aſpect of Medea in the act of infanticide; and which, becauſe incapable of being heightened, would leave no room to the productive power of imagination, which it is the office of painting rather to excite than to ſaturate. Perhaps above all others the following is the moſt appoſite inſtance: Junius Brutus is graphically deſcribed by Livy as preſiding at the capital puniſhment of his ſons, whom he

he had condemned to die; *& qui ſpectator erat amovendus, cum ipſum fortuna exactorem ſupplicii dedit - - - - - quum inter omne tempus pater, vultus & os ejus ſpectaculo eſſet.*

But what appearance in the countenance of Brutus ſo ſtrongly intereſted the attention of the beholders? They ſurely ſaw ſomething more than the expreſſion of a father's heart wounded by the ſufferings of his ſons. They traced a ſevere internal conflict; they obſerved viſibly characſtered in his face and geſture the vigorous but ineffectual efforts of nature to burſt the reſtraints with which ſtern republican juſtice had fettered her yearnings: *Eminente patrio animo inter publicæ pœnæ miniſterium.*

An ESSAY *on the* ART *of* CONVEYING SECRET *and* SWIFT INTELLIGENCE. *By* RICHARD LOVELL EDGEWORTH, *Esq. F.R.S. and M.R.I.A.*

Read June 27th 1795.

THE art of conveying intelligence by ſounds and ſignals is of the higheſt antiquity.—It was practiſed by Theſeus in the Argonautic expedition, by Agamemnon at the ſiege of Troy, and by Mardonius in the time of Xerxes. It is mentioned frequently in Thucydides; it was uſed by Tamerlane*, who had probably never heard of the black ſails of Theſeus; by the Moors in Spain, and by the Welch in Britain; by the Iriſh, and by the Chineſe on that famous wall, by which they ſeparated themſelves from Tartary.

THESEUS furniſhed his ſhip Argo with black ſails as prophetic mourning for his expected fate; but he promiſed, that if he were ſucceſsful he would upon his return put up a white ſail to inform his father and his countrymen of his ſafety. Fluſhed with victory the young telegrapher forgot his ſignal. The Athenians on

* Vertot's Knights of Malta.

on the ſhore watched with eager eyes for his return; old Ægeus ſaw the black ſignal, and certain that his ſon was dead, he threw himſelf from a rock into the Ægean ſea †.

The ſignals of Agamemnon are beautifully deſcribed in Æſchylus, and every ſtation is pointed out with geographical accuracy.

Tamerlane's telegraphy was not very refined, but it was ſufficiently intelligible. Whenever he laid ſiege to any town he uſed to employ three ſignals—the firſt day he ſet up a white flag, to ſignify that he was diſpoſed to uſe clemency to thoſe who immediately ſurrendered; the ſecond day his ſignal was red, to ſignify that he would have blood, and that the lives of the governor and of the principal officers of the garriſon muſt pay for their temerity; but the third day his black ſtandard declared that whether the place ſurrendered or was taken by ſtorm every body ſhould be put to the ſword and the town utterly deſtroyed.

The Moors built many towers in Spain; they were placed on the principal eminences in the kingdom, from whence, by means of lights and ſignals, they could correſpond with each other. Theſe towers in many places ſtill remain‡. The celebrated

† Perhaps Cervantes recollected the black and white ſails of Theſeus when he wrote his Galatea.

‡ The Aſiatics and Arabs practiſed the art of ſpeaking by ſignals, as we are told by Haſſelquiſt and Marigni.

brated Mr. Pennant has diſcovered and traced with great accuracy a long ſeries of ſtations in Wales from Penbedu to Cop yr Goleuni, or Hill of Fire; theſe he enumerates in Cambrian orthography, with which I ſhall not ſwell this paper.

Boethius ſays that in his time there ſtill were left in many places in Britain remains of huge poles on which barrels of pitch were elevated to give ſignals by night and day; and it is ſaid that the cuſtom of lighting fires in Ireland upon St. John's eve is a commemoration of antient ſignals by fire.

The deſcription of the wall of China is familiar to us, but it implies ideas of extent and magnitude beyond our habits of compariſon, and ſcarcely within the reach of imagination. We can form no adequate idea of a wall fifteen hundred miles in extent, peopled with centinels who can ſpread an alarm with the celerity of an electric ſhock through the nerves of a vaſt empire.

Different methods were uſed by the antients for the rapid communication of intelligence—by ſight and by ſound. Smoke by day and fires * by night were the uſual ſignals of particular

 events;

* As the papers of this Academy fall into the hands of the fair ſex I muſt not omit paying due honour to the memory of Hero and Leander. The poem of Muſæus is almoſt forgotten; this will never be the fate of the following beautiful lines of a modern poet:

" So

events; theſe ſignals by degrees were applied to an alphabetical arrangement, which is minutely deſcribed by Polybius. The ancients had a much more ingenious contrivance, that contains the principles of all the improvements which have ſince been made on this ſubject. The Clepſydra was uſed like an hour-glaſs, to count time; it conſiſted of a tall veſſel with a hole at the bottom, through which water paſſed ſlowly. The deſcent of the ſurface of the water marked the lapſe of time: Two ſimilar Clepſydras, with the addition of a floating gauge in each, on which different ſentences were inſcribed, were ſet in motion at once by a ſignal, and were ſtopped by another ſignal when the ſentence on the floating gauge deſcended to a certain index. But a ſtill more compendious method of communication was ſuppoſed to exiſt in the 16th century. It was reported that two magnetic dials, with the four-and-twenty letters inſcribed on their circumference, would by means of ſelf-moving hands point to the letters which the correſpondents meant to indicate. The great Bacon believed in thoſe ſympathetic dials, and the learned

" So on her ſea-girt tower fair Hero ſtood
" At parting day, and marked the daſhing flood;
" While high in air the glimmering rocks above,
" Shone the bright lamp, the pilot ſtar of love—
" With robe outſpread the wavering flame behind
" She kneels, and guards it from the ſhifting wind;
" Breathes to her goddeſs all her vows, and guides
" Her bold Leander o'er the duſky tides."

DR. DARWIN's Botanic Garden.

learned Sir Thomas Browne, in his enquiry concerning vulgar errors*, gravely informs us that he procured two dial plates, according to directions, magnetiſed the needles, and repeated the experiment in form, but to his infinite diſappointment, " the " needles, though but a ſpan removed from each other, ſtood like " the pillars of Hercules :" He then proceeds to confute the theory " of this excellent (and if the effect would but follow) " divine conceit," by ſhewing that magnetic needles ſhould influence the motions of each other, not in the ſame, but in contrary directions; had this been the only difficulty, it had been eaſily obviated by reverſing the order of the letters in one of the alphabets.

Doctor Johnſon, in his life of Browne, laughs at him for having taken the pains to try " ſuch a hopeleſs experiment," remarking " that he might have ſatisfied himſelf by a method " leſs operoſe, by thruſting two needles through a cork and " ſetting them afloat in two baſons of water;" but Browne, he obſerves, " appears indeed to have been ready to pay labour for " truth."

The ſtory of theſe dials had, I believe, ſome foundation, but, as it uſually happens in popular ſtories, much fiction has been mingled with ſome truth.

* Book 2d, page 57.

If two clocks were furniſhed with hands, and with dial-plates containing the alphabet, the motion of each of them might be unlocked at a momentary flaſh or ſound, and they might be ſtopped together at any letter by a ſecond exploſion. I am informed that a very ingenious member of this Academy has ſpoken of ſuch a contrivance*—With proper precautions, and by ſubſtituting numbers correſponding with a vocabulary inſtead of an alphabet, this invention may be perfected. I cannot help remarking, that by the experiment of Sir T. Browne with two diſtinct dials, &c. a hint might have been obtained of a practicable contrivance; but by Doctor Johnſon's cork, with two needles thruſt through it, nothing could be obtained but diſappointment. Vulgar tradition and poetic allegory are neither to be implicitly truſted nor haſtily deſpiſed†. The incredulity of mankind in ſome inſtances appears as ſurpriſing as their credulity in others. The diſpoſition to ridicule every ſcientific project as abſurd until it has been abſolutely brought to perfection has been the common topic of complaint amongſt men of inventive genius; and it is curious to obſerve that poets, who ſuffer ſo much themſelves by the taunts of men of the world, and by the apathy of the vulgar, ſhould in their turn revenge themſelves

* A ſimilar contrivance is mentioned in Hooper's Rational Recreations.

† In a beautiful Arabian tale, written perhaps a hundred years before the time of Gallileo, in which we expect nothing but fiction and extravagance, we find that the air balloon and the teleſcope are introduced in the contrivance of the fable.

ſelves upon men of ſcience, and treat their ſpeculations with diſdain. Ben Johnſon has attempted this in one of his maſques with a degree of humour which is not always the portion of thoſe who throw ridicule on ſcience. Merefool, the clown of the piece, conſults an adept, who promiſes to inſtruct him in all occult ſecrets, and to ſhew him apparitions of all the learned men of the ancients; but every man who is called for happens to be buſy, from Pythagoras "who has raſhly run himſelf upon "an employment of keeping aſſes from a field of beans," to Archimedes, who is meditating the invention of

"A rare mouſe trap with owls wings,
"And a cat's foot to catch the mice alone."

Not only the ſame taſte for ridicule, but the ſame ideas we find repeated, with a ſlight alteration, at different æras; Ariſtophanes and Lucian amongſt the ancients*, and Butler†, Swift

* A balloon may be carried forward with certainty and celerity in any direction where there is no perceptible wind, if it is alternately lowered and elevated by altering from time to time its ſpecific gravity, which may be done by various means without loſing much hydrogine gas; and if it be furniſhed with fins or ſmall ſails and be ſet to a proper angle with its line of aſcent and deſcent, their vertical preſſure againſt the air will impel the balloon forward.

Swift manœuvres his Laputa in this manner.

I tried this invention on a ſmall balloon in the houſe of the late ingenious Dr. Uſher, the friend of ſcience, and of thoſe who wiſhed to improve it.

† See Butler's ridicule of the ingenious idea of making uſe of pendulums for a univerſal meaſure. Canto 3d, page 87.

Swift and Voltaire, the three great modern maſters of ridicule, have in various ſhapes the ſame ideas, and are alike diſpoſed to confound the ingenious and the extravagant. The beſt way of parrying the ſtroke of ridicule is to receive it with good humour; laugh with thoſe who laugh, and perſevere with thoſe who labour, ſhould be the motto of men who poſſeſs the powers of invention.

The late Doctor Johnſon, who in his Raſſelas ridiculed the idea of the art of flying, lived long enough to ſee the aſcent of the firſt air balloon.

Several attempts have been made to convey ideas by ſounds louder than the human voice. Even the voice of Stentor was inſufficient to reach a whole army, and the ſpeaking trumpet * was invented to convey the orders of the general in the field of battle. It is mentioned in Æſchylus; and Alexander is ſaid to have poſſeſſed a trumpet of ſuch aſtoniſhing powers as to convey his commands to the diſtance of one hundred ſtadia, nearly twelve miles.

Thoſe who wiſh to turn their attention to the improvement of ſpeaking trumpets, of tubes, or of buildings for magnifying ſound,

* Sir T. Morland and Kircher diſputed long and loudly their reſpective claims to the invention of the ſpeaking trumpet. It is ſingular that the latter ſhould forget the ſtentorophonic tube of Alexander, the figure of which is preſerved in the Vatican.

ſound, will be pleaſed with an ingenious memoire of Beaumur's in the Academy of Sciences †. "Sur le ſon que rend le "plomb en quelques circonſtances," with the obſervations of Monſ. Sauveur‡. The memoire of Maupertius § upon muſical inſtruments—An excellent ſet of experiments by M. L'Abbè Nollèt‖, "Sur la tranſmiſſion des ſons dans l'eau;" and a ſhort letter amongſt the miſcellaneous papers of the judicious Franklin, will probably be found uſeful.—Nor will any man of genius neglect the enthuſiaſtic predictions of our great philoſopher Doctor Hooke*. In his method of improving Natural Philoſophy he ſpeaks of the inſtruments which may be contrived to enlarge the powers of our ſenſes. He ſubjoins to what he ſays on the ſenſe of hearing the following apology:

"METHINKS I can hardly forbear to bluſh when I conſider "how moſt people will look upon this, but yet again I have "this encouragement, though theſe things be never ſo much "derided by the generality of men, and never ſo ſeemingly mad, "fooliſh, or phantaſtical, that as the thinking them impoſſible can-"not much improve my knowledge, ſo the believing them poſ-"ſible may perhaps be an occaſion of my taking notice of ſuch "things as another would paſs by as uſeleſs."

THIS is not enthuſiaſm, but ſound ſenſe;—men of enlarged minds admit univerſal toleration for conjecture and theories, becauſe

† M. 1726, page 243. 464. ‡ Hiſtoire 1701, page 25.
§ Memoires 1724, page 215. ‖ Memoires 1741, page 199.
* Doctor Hooke's Poſthumous Works.

cauſe they conſider them as the means of rouſing activity, and of exciting to experiment and patient obſervation. A man who has a theory to ſupport muſt concentrate his attention, and will quit the idleneſs of mere ingenuity for that induſtry which leads to truth—aſſertions and declamation he knows will avail him little; facts, which ultimately decide all arguments, muſt be ranged under his banners, if he aſpire to the honours of a triumph; nor is it by any means neceſſary that the ſpectators ſhould be partizans; the moſt complete indifference may be preſerved as to the theoriſt, and even as to the theory.

I THOUGHT it neceſſary to mention the attempts which have been made to communicate intelligence ſwiftly by ſound, and to remark that it is probable that this art may be brought in time to high perfection. Though I prefer different methods I would not diſcourage others, nor keep my own mind ſo intent upon one object as to prevent my obſerving what may be worth my conſideration in another.

THE telegraphic art was chiefly confined to war amongſt the ancients; but we have reaſon to conjecture that it was alſo ſecretly employed in the management of oracles. Fontenelle believed that the oracles at Delphi and at other places were delivered through pipes, which communicated with the apartments of the prieſts*. Beſides contrivances of this ſort, is it abſurd to ſuppoſe

* P're Balthus oppoſes this opinion of Fontenelle's in his anſwer to the Hiſtory of Oracles.

ſuppoſe that they poſſeſſed ſome ſecret mode of receiving intelligence from the ſeveral nations who conſulted them?

Croesus, after having been duped by various oracles began to ſuſpect their infallibility, and to obſerve that they made bad verſes; he reſolved to try their powers of divination before he put himſelf to any farther expenſe in coſtly offerings. At a certain hour, on a particular day and at an appointed moment, the meſſengers whom he had diſpatched to the different oracles demanded from them "What was at that inſtant the employment "of Crœſus?*

All the oracles were mute, except the Delphic, which immediately anſwered the meſſengers of Crœſus in theſe *inſpired* lines †.

"I know the ſpace of ſea—the number of the ſand,
"I hear the ſilent—mute I underſtand.
"A tender lamb, joined with tortoiſe fleſh,
"Thy maſter, king of Lydia, now does dreſs;
"The ſcent thereof doth in my noſtrils hover,
"From brazen pot cloſed with brazen cover."

* Herodotus, 1ſt vol.

† I have preferred this tranſlation to all others, as beſt ſuited to the oracle.

This was preciſely the ſtrange employment which the king had privately deviſed for himſelf. The anſwer of the oracle aſtounded and convinced Crœſus, and ſeems to have had as powerful an effect upon Sir Thomas Browne, who in his "Enquiry concerning Vulgar Errors," calls this the plaineſt of all oracles, and deems it the cleareſt proof of their ſupernatural agency. Neither probability nor coincidence could have produced this marvellous reply; it has therefore excited alike the aſtoniſhment of the learned and of the ignorant. But the wonder ceaſes, and an eaſy ſolution of the difficulty preſents itſelf, if we ſuppoſe that the prieſts of the oracle were Telegraphers.

It is probable that ſignals were firſt employed for defence to give notice of an approaching enemy. The ſtupendous wall of China does not appear to have been intended for a barrier againſt the Tartars as a nation; it was probably meant as a defence againſt their occaſional inroads as banditti. To embodied enemies it would have preſented no inſurmountable obſtacle, but againſt detached marauders it was an effectual fence. Gibbon ſeems not to have perceived the real intention of this laborious work; he ſpeaks of it conſequently with too little reſpect when he affirms that "it has never contributed to the ſafety of an "unwarlike people." It is true that their ſavage enemies have upon ſome occaſions, "by their rapid impetuoſity, ſurpriſed, aſ-"toniſhed and diſconcerted the grave and elaborate tactics of a "Chineſe army." But war was never the taſte or buſineſs of this

this automatic nation; ſurrounded by hordes of banditti, their wiſh was uniformly to preſerve the methodical regularity of peace. It will be allowed that it was no eaſy taſk to make their circumſtances and their taſte agree; yet they have quietly gained their point, and they have lived the ſame life for thouſands of years. Their dynaſties have changed, but the nation has remained the ſame.

The exiſtence of their empire is the beſt proof of its policy, and the beſt argument to demonſtrate that art and ſcience, if we take time into the account, are able to conquer force and numbers—if we take time into the account; for many of the miſtakes in our reaſonings, and in the concluſions that we draw from experiments, in moral as well as in natural philoſophy, have ariſen from our omitting *time* in our calculations.

It was the policy of the Romans, which ſecured to them the dominion of all the countries which they conquered, to eſtabliſh wherever they went methods of communication and ſwift intelligence. Their laborious roads, their forts, their military obſervatories, are all proofs of their conſummate ſkill in the arts of government and of war. It is not neceſſary to expatiate upon facts with which every perſon of literature is acquainted. The remains of theſe public works may eaſily be traced. Amongſt many others the lofty towers which are to be ſeen at Uzes, Bellegarde, Arles, and an antient building called "The Tourmagne" at

Niſmes *, were Roman watch towers, from which the Roman guards communicated intelligence to each other by ſignals, of whatever paſſed in the ſurrounding country. The advantages of this univerſal facility of intercourſe through a vaſt extent of empire, divided by nature, and united more by art than arms, were peculiarly felt. The capitals of Syria, Egypt, Antioch, and Alexandria, with a croud of dependent cities, eleven hundred and ninety-ſeven in Italy, twelve hundred in Gaul, three hundred and ſixty in Spain, three hundred African, and five hundred populous Aſiatic cities "ſwell the aſtoniſhing liſt of theſe dominions." All theſe cities were connected with each other, and the great chain of communication from the north-weſt to the ſouth-eaſt point of the empire was drawn out to the length of about 3740 Engliſh miles. "† It was the advantage of receiving the earlieſt "intelligence and of conveying their orders with celerity, which "induced the emperors to eſtabliſh throughout their extenſive "dominions the regular inſtitution of poſts."

It is not from any pedantic reverence for antiquity that I appeal to precedents. Precedent, either antient or modern, is liſtened to by men of ſenſe only as being the voice of experience, not from its aſſuming the tone of authority. The legiſlation and manners of the modern world differ ſo much from thoſe of the antient, that it would in many caſes be abſurd to apply their maxims to our ſituations; and notwithſtanding the great undertakings

* Antiquities de Niſmes. † Gibbon, vol. 1ſt, p. 60.

takings of the antients, the modern improvements of ſcience give us evident ſuperiority in ſeveral of the arts of life and of defence.

Science is no longer recluſe, no longer inveloped in myſtery, or ambitious only of idle admiration; ſhe has diſcovered that to be eſteemed by men ſhe muſt be uſeful.

In the preſent times as in the paſt the power of executive government in every ſtate muſt in a great meaſure depend upon the celerity and accuracy of its intelligence: "Firſt to watch "and then to ſpeed," is one of Lord Bacon's political maxims; he adviſes to "commit the beginning of affairs to Argus with "his hundred eyes, and the end to Briareus with his hundred "hands." The hands that can execute are in every ſtate more eaſily found than the eyes that can obſerve.

Whilst government is uncertain from what quarter an attack may come, or in what part of the country commotions may ſuddenly ariſe, the means of aſſiſtance muſt be immediately at hand in various parts; nor whilſt information is tardy or imperfect can the force be proportioned to the danger; there is perpetual hazard of profuſion or neglect. But, on the contrary, if from day to day and from hour to hour intelligence could be received from all parts of a country, there would be time for combination and arrangement; the force of a kingdom could be collected by a wiſh and directed by a word. The certainty which the people would

would have of the immediate ſuperintendence of their governors would create confidence in the good, and apprehenſion in thoſe who are diſpoſed to miſchief. It is not the ſeverity and the duration of puniſhment, but its certainty and its immediate connection with the crime, which act moſt forcibly upon the human mind. No means can be more likely to prevent diſobedience to the laws, either civil or military, than thoſe which increaſe the probability of ſpeedy detection. What man would attempt to fly from the civil power who knew that his flight would be advertized through the kingdom in a few minutes, and that the deſcription of his perſon with the publication of his offence would infallibly meet him wherever he went? With ſuch advantages government would not be obliged to keep an extravagant force in diſplay to create reſpect.

WHOEVER attends to ſecret hiſtories and private memoirs, from "The diary of Bob Dodington" to the ſhameleſs "Secret "Hiſtory of the Court of Berlin," will be convinced of the anxiety of courts and courtiers for early intelligence. Mirabeau paints in ſtrong colours his anxiety to give his employers at the French court the *carlieſt intelligence* of the death of the king of Pruſſia. His own perplexity, and the buſtle amongſt rival courtiers and ambaſſadors, are well deſcribed:—the conſequence of carrier-pigeons and couriers, and the expenſe which Mirabeau was commiſſioned to defray, ſhew the value which the court of Verſailles annexed to his ſucceſs*.

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* Mirabeau's Secret Hiſtory of the Court of Berlin, Page 50.

As this is not a memorial for miniſters, but a paper addreſſed to a philoſophical ſociety, I may without impropriety remark, that he " who ſmote the houſe of Bourbon with one hand, " and in the other wielded the democracy of England," was ſuppoſed to have had the beſt intelligence of any miniſter that ever preſided over the Britiſh councils. It was this circumſtance which gave a ſecret power to his eloquence over the minds of thoſe who knew that his prophetic ſtrain was the language of political experience, not of ignorant enthuſiaſm. His words, in a ſpeech on the commencement of hoſtilities with Spain, were remarkable.

" I do now pledge myſelf to this honourable houſe for the " truth of what I am going to aſſert—that at this very hour " that we are ſitting here together, there has been a blow of " hoſtility ſtruck againſt us by our old inveterate enemies in " ſome part of the world."

This prediction, if it was a prediction, was almoſt immediately verified; the next poſt brought news, that the blow of hoſtility had been ſtruck at Falkland's Iſlands.

The advantages which by means of Telegraphy would reſult to commerce muſt, both in time of war and peace, be extenſive. In time of war the ſafety, I might almoſt ſay the exiſtence, of the commercial world, depends upon the rapidity and the accuracy of its intelligence. The relative ſucceſs of merchants,

merchants in their ſeveral ventures and ſpeculations muſt be regulated by the extent of their information, and by their capacity to apply that information to their conduct. To equalize their capacity is impoſſible; there will always remain a conſiderable difference between the underſtandings of men, ſuppoſing them to be in poſſeſſion of the ſame facts; but, to thoſe who can reaſon, the great difficulty is to arrive at facts that may form juſt data for their reaſoning. Here I flatter myſelf Telegraphy can materially ſerve them, nor will they be inclined to treat with diſdain any attempt of ſcience to abridge the routine of buſineſs.

It is curious and ſometimes amuſing to obſerve how any new invention implicates different intereſts, and how different claſſes of ſociety are immediately or remotely affected by circumſtances in which they did not imagine themſelves to be in any way concerned. A ſtock-jobber, in glancing his eye down a column of a newſpaper, would ſkip over a paragraph about a Telegraph, as news from the regions of ſcience, in which he could have no manner of intereſt. Science and ſtock-jobbing do not indeed appear to bear any near affinity to each other, nor ſhould we expect that a mechanic invention would have any powerful effect upon the rate of inſurance; yet the eſtabliſhment of Telegraphs in proper places would produce a great revolution at Lloyd's and on the Exchange.

THE profits of infurers, which do not depend on gambling but on calculation, would be raifed, not in the immediate increafed rate of infurance but in the certainty of the revenue. In proportion as their intelligence was expeditious and authentic they could afford to infure on lower terms, becaufe their bufinefs would become more extenfive, and becaufe the hazards arifing from ignorance of foreign and domeftic events would, to them, be confiderably diminifhed.

I AM fenfible that the gambling ftock-jobber, and all thofe concerned in the infurance of lotteries, ought, if they underftood their own intereft, to confider this invention as the ruin of their trade. Whatever brings the conduct of affairs within the limits of calculation, and enlarges the power of prudence, diminifhes the empire of fortune, and muft be deprecated by gamefters of every defcription. A ftock-jobber traffics in the ignorance and credulity of his neighbour, againft which he ftakes his own information and cunning, and fometimes his rafhnefs and prefumption. His bufinefs is to collect intelligence, and to conceal or divulge it as may fuit his intereft. He lives by the news of the day and by the report of the moment; but fince news, even with all the activity he can employ, cannot be circulated from kingdom to kingdom, through the ftreets of London, the coffee-houfes and the exchange, with the fame velocity by the human tongue as by the Telegraph, he will hate and fear it as his rival and detector; nor will any man of bu-

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ſineſs, any philoſopher, nor yet any honeſt man, feel the ſlighteſt compunction at the idea of deſtroying the profits of a claſs of ſpeculators unproductive to the wealth and noxious to the morality of the community.

It has been obſerved by Smith, that mankind are wonderfully diſpoſed to truſt to their individual good fortune, contrary to the general experience of human affairs. This propenſity has lately been apparent in the commercial world, and it would be in no ſmall degree ſerviceable to its intereſts to bring back the attention of the merchant from chance to induſtry.

To give an inſtance of the effects that might be produced by immediate and univerſal communication in the affairs of commerce I need only mention the corn trade. The advantage of the weekly corn returns from different parts of England have been ſenſibly felt; and if ſuch returns would be daily made combinations would be prevented in every market in the kingdom.

The celebrated author of "The Wealth of Nations" has ſo clearly developed the connexion between freedom of intercourſe in ſociety and the intereſts of commerce, between the facility of communication in kingdoms, and the demand for the neceſſaries, or the taſte for the luxuries of life, that it would be impertinent to repeat obſervations which he has impreſſed upon the public conviction,

conviction, or to explain what he has demonſtrated. But the facts which he has with ſo much accuracy and elegance arranged in ſyſtematic order have been remarked in detail by others in the common buſineſs of life, for on theſe common obſervations compared and arranged all ſyſtems that are juſt muſt be founded.

EVERY perſon muſt have obſerved the effect which quick and eaſy communication between the parts of a country has upon its proſperity. With the faculty of gratifying our taſte for the conveniencies of life the taſte itſelf encreaſes, and whatever facilitates the means of giving *orders* encreaſes the productions of induſtry.

BY this freedom of intercourſe, as both expenſe and time are ſaved, the conveniencies, comforts and innocent luxuries of life are brought within the limits and reach of our prudence. Telegraphy we may flatter ourſelves will extend theſe limits, and "will bring our wiſhes nearer to our view*."

THERE is no reaſon to doubt that ſuch a communication will exiſt between the different parts of the European continent and

* Puck promiſes Oberon to put a girdle round the earth in forty minutes. It is not phyſically impoſſible (I do not ſpeak of probability) to ſend a meſſage from the extremity of Siberia to Cape Horn and to receive an anſwer in twenty minutes.—a time and ſpace nearly equal to the fiction of Shakeſpeare

Great Britain when peace ſhall be eſtabliſhed*. The general advantage of an immediate and ſpeedy communication between this country and Great Britain are ſufficiently obvious, both with reſpect to their unity of intereſt and their commercial intercourſe. Our legiſlation and manners are the ſame with thoſe of the Engliſh, and all means which contribute to unite the minds and intereſts of the people muſt be advantageous to both nations.

At preſent an expreſs cannot reach London from Dublin in leſs than forty hours. By the Telegraph a meſſage may be conveyed in as many minutes. At the ſame rate a correſpondence may be maintained with Cork with the ſea ports of Great Britain, and with any place where ſuch communication may be required.

I should not omit to point out to this learned and patriotic Academy the uſes to which the Telegraph may be applied in the purſuits of ſcience. One of our members, as highly diſtinguiſhed by his taſte and love for literature, as by his munificence, propoſed to the late Dr. Uſher the meaſurement of a baſe in Ireland for the conſtruction of a ſeries of triangles, to be connected with the operations of General Roy in Great Britain and France. The Doctor did me the honour to aſſociate me in this undertaking;

* I ſcarcely dare to foretel that a communication by Telegraphs between Europe and the Eaſt Indies will one day be eſtabliſhed, and that its effects will be more beneficial to Europe than monopoly or conqueſt.

taking; and the laſt lines, which I believe he ever wrote, were upon this ſubject. In a philoſophical enterpriſe of this extent, as General Roy has feelingly remarked, there are more difficulties to be overcome, and more expedients required, than could be eaſily foreſeen. Three ſummers were conſumed in operations that it was ſuppoſed would have been accompliſhed in two or three months; and a great part of this delay aroſe from the neceſſity of keeping up conſtant communications with diſtant obſervers. If the Telegraph were employed in ſuch a ſurvey the buſineſs might be conducted with eaſe and ſatisfaction; the irkſome interruptions ariſing from the diſtance of ſtations would be avoided, and every ſtep would be progreſſive.

The ſcience of meteorology, which has lately been cultivated with ſo much good ſenſe by Mr. Kirwan, might receive great aſſiſtance from the Telegraph, when eſtabliſhed in the principal parts of this kingdom and of Great Britain: A communication ſwifter than the wind would prepare the attention to obſerve thoſe phœnomena in different places, which are ſuppoſed to precede ſtorms and fair weather. The manometer in particular might be corrected from the compariſon between diſtant obſervations made at the ſame moment.

Whenever the aeroſtatic balloon is employed for the purpoſes of ſcience, the power of communication between the clouds and the earth, between different balloons at various heights and

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in various places by Telegraphy, will tend to improve our knowledge in many parts of ſcience. Public curioſity and private gain have been amply ſatisfied by various aeroſtatic exhibitions. Balloons will, I hope, ſoon become an object of different ſpeculation; and at ſome place diſtant from the capital and from any large city, they will I hope be employed at leiſure to enlarge our knowlege of the atmoſphere, of dioptrics acouſtics, pneumatick chemiſtry, and of the animal œconomy, ſo far as it is effected by the different preſſure and different qualities of the higher regions of the atmoſphere.

There is another important ſcientific uſe to which Telegraphy may be applied—it may ſerve as an introduction to an univerſal language.

The idea of a univerſal character and philoſophical language, which all nations ſhould be able to write and underſtand, has been treated by many as chimerical, becauſe it has not yet been brought to perfection. The Jeſuits, by the accounts their miſſionaries ſent home of the peculiarities of the Chineſe language, fixed the attention of men of learning and ingenuity upon this ſubject The defects and ſingularities of that language afforded them ample matter for reflection. The Chineſe have no alphabet of ſimple ſounds like ours; no elementary characters like our letters, from the combination of which European languages are formed. They have two ſepa-

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rate languages, one oral, to ſerve for the common purpoſes and buſineſs of life, conſiſting of about three hundred words; the other, which is reſerved for the uſe of the literati, for hiſtory, poetry and ſcience, compriſes ſixty thouſand or eighty thouſand * different characters. As they have no alphabet, each diſtinct idea and each variation of a thought, inſtead of being expreſſed by the different arrangement of the ſame letters, muſt be denoted by a ſeparate character or an appropriate inflexion. The labour of learning theſe is the labour of a life. Scarcely any of their manderines pretend to underſtand the whole of the language, and a manderine who at fifty can boaſt that he knows half his characters is accounted in China a very learned man. Their popular language has likewiſe a defect which we ſhould think muſt be every day felt by all claſſes of people. Each of its three hundred words, when pronounced in different tones, expreſſes totally different things; and the ſlighteſt inflexion of the voice entirely alters a man's meaning; ſo that thoſe who have the misfortune to have a bad ear muſt conſequently, in China, have a bad underſtanding. The ſyllable *Ko* has ten different modes of pronunciation; and *Ba*, according to its various accents, has ſix ſeveral ſenſes, which bear no affinity to each other. The moſt expert orators in the nation often find it impoſſible to make themſelves underſtood without ſeveral attempts and repetitions to explain themſelves; and ſometimes they

* Du Halde.

they are forced to conclude by † making the figure of the character they would expreſs with their fingers in the air or upon a wall or table.

With ſuch orators action is every thing! To make the affairs ſtill more complicate, the different provinces of China ſpeak different dialects, incomprehenſible to each other; but they have one common written character which all the provinces and alſo the Japaneſe underſtand and can read off in their ſeveral tones into their reſpective languages—this ſhews the poſſibility of a univerſal character being brought into actual uſe.

Bishop Wilkins, in his "Eſſay towards a Univerſal Character," as he modeſtly calls it, has diſplayed wonderful ingenuity and a moſt comprehenſive mind. His characters are formed on principles of philoſophic arrangement, ſo that the ſight of any character deſigned to denote a complex idea ſhall by different lines or points repreſent or bring to our recollection all the ſeveral parts of which that idea is compoſed. Thoſe characters which denote ſubſtances or animals expreſs by ſlight differences at once the ſpecies and genera to which they belong. This idea of claſſification he traced in a few inſtances in the Chineſe language. The Chineſe character, that ſignifies metals, with ſlight additions, diſtinguiſhes

† Wilkins.

tinguiſhes iron, copper, ſteel, &c.*; and the character uſed for a precious ſtone, with certain variations, means different kinds of gems or pearls. Independently of his general ſyſtem his remarks upon conjunctions and particles are excellent for his time, though a late ingenious publication † has ſhewn the miſtaken principles upon which he and all former grammarians had reaſoned upon the ſubject. Doctor Wilkins's characters for irony, and to give warning that a word is uſed in a figurative or rhetorical ſenſe, might be uſed with as great advantage as the common notes of interrogation and admiration. The warning note might not be approved of by poets, wits and orators, becauſe it would leſſen the effect of repartee, declamation, and perhaps of the ſublime, which requires ſome degree of obſcurity to captivate the imagination, or of ſurprize to aſtoniſh the underſtanding: But where accurate knowledge, rather than amuſement, is required, ſuch an aſſiſtance would be agreeable. Thoſe who have turned their thoughts towards education will immediately perceive its utility in another point of view. By the help of this note children would underſtand part of the poetry which they are *obliged* to learn by heart.

It is not poſſible to explain Wilkins's ſyſtem in a few words: Allowing for the phraſeology of his time his copious folio is ſcarcely too large to do juſtice to his ideas.

* See an ingenious Eſſay on Symbols and on Characters uſed by Chemiſts; by Dr. M. Wall.—Mem. of Phil. Soc. Mancheſter, 1ſt vol.

† ΕΠΕΑ ΠΤΕΡΟΕΝΤΑ.

When I was arranging a vocabulary for the telegraph, I looked over his work, and recalled to my mind ideas upon the ſame ſubject, which have for years, at intervals, employed my attention.

It has employed the talents and attention of ſeveral men of learning and ability, and it appears to be a ſubject worthy of their time and labour, and highly inviting to future induſtry and invention.

Fontenelle, in his Eloge on Leibnitz, mentions his intention of making out an alphabet of human thoughts, for a philoſophical language; but his death put a ſtop to the deſign. This intention I have found obſcurely mentioned at the end of his ingenious Memoire on Binary Arithmetic, where he ſpeaks of "a new character," which he projects—A tranſlation, perhaps, might not do juſtice to the meaning, I therefore will quote his words:

"C'eſt que tout raiſonnement qu'on peut tirer des notions "pourroit etre tirè de leur caracteres, par une maniere de calcul "qui ſeroit un des plus importants moyens d'aider l'eſprit "humain*."

M. Leibnitz told Boyle, "that though Wilkins and Dal-"garme were great men, he did not think they had hit their "point.

* Memoires de l'Academie de Science, 1703. m. page 111.

" point. They might," he ſaid " by means of their languages, " enable nations who were ſtrangers to each other to converſe " together, but they had not caught the true real characters, which," he ſaid, " ſhould reſemble algebraic characters, which would in- " finitely aſſiſt the memory and invention." If Leibnitz could have found theſe real characters, the greateſt difficulty, as Fontenelle obſerves, would have ſtill remained, to have perſuaded mankind to agree in the uſe of them.

Lavoisier, who invented, on truly ingenious and philoſophical principles, a new language for chemiſtry, found it for ſome time difficult to introduce it amongſt chemiſts; and the characters which, with the approbation of the Academy of Sciences, Monſ. Berthollet has annexed to Lavoiſier's vocabulary, have never been adopted in the ſcientific world.

The averſion which the learned, as well as the vulgar, have ſhewn to adopt any univerſal language that has ever yet been propoſed to them, ariſes from various cauſes. The peculiar aſſociations and habits of different perſons are incompatible, ſo that an arrangement of ſounds or ideas, which may be convenient to the memory of one perſon appears prepoſterous to the judgment of another; and the analogies which ſtrike the underſtanding of one claſs of people are ſo foreign to the minds of another that they tend rather to bewilder and diſguſt than

to pleaſe and aſſiſt the imagination. Beſides this there is a difficulty which ariſes from the vanity of each individual, who fancies that in a new coinage of language his own authority would be ſufficient to give credit and currency to any new words he wiſhed to bring into circulation.

The preſs is an engine which every perſon can make uſe of to convey his ideas to the public, and as long as any objection can be made to the introduction of new characters it is not probable that they ſhould be admitted, becauſe every perſon is confirmed by habit, vanity or immediate convenience, in the uſe of the eſtabliſhed mode of expreſſion. But when a man wiſhes to convey his ideas to foreigners who do not underſtand his language, or whoſe language he does not underſtand, he truſts with confidence to his interpreter, and is content to catch, at ſecond hand, ſome knowledge of the terms which are employed in his ſervice—he ſubmits from neceſſity to what he would not ſtoop by choice. When all competition ceaſes men are willing to learn voluntarily what they would never have condeſcended to be taught by compulſion.

In this point of view it appears to me that the Telegraph would be an eaſy and certain means of introducing a univerſal language, and of improving it by degrees without any extraordinary effort. The object would be accompliſhed before it was ſuſpected, and it would be ſubject to leſs oppoſition when preſented

preſented as an incidental than when introduced as a primary conſideration. At preſent I ſhall not attempt to enter upon ſuch an extenſive enquiry as into the means of forming an univerſal language, but at ſome future period I hope to offer my thoughts upon this ſubject to the Royal Iriſh Academy.

HAVING ſlightly mentioned the contrivances made uſe of by the antients for conveying intelligence ſwiftly, and having pointed out ſome of the various important uſes to which this art may be applied, I ſhall endeavour to give a clear view of my attempts on this ſubject.

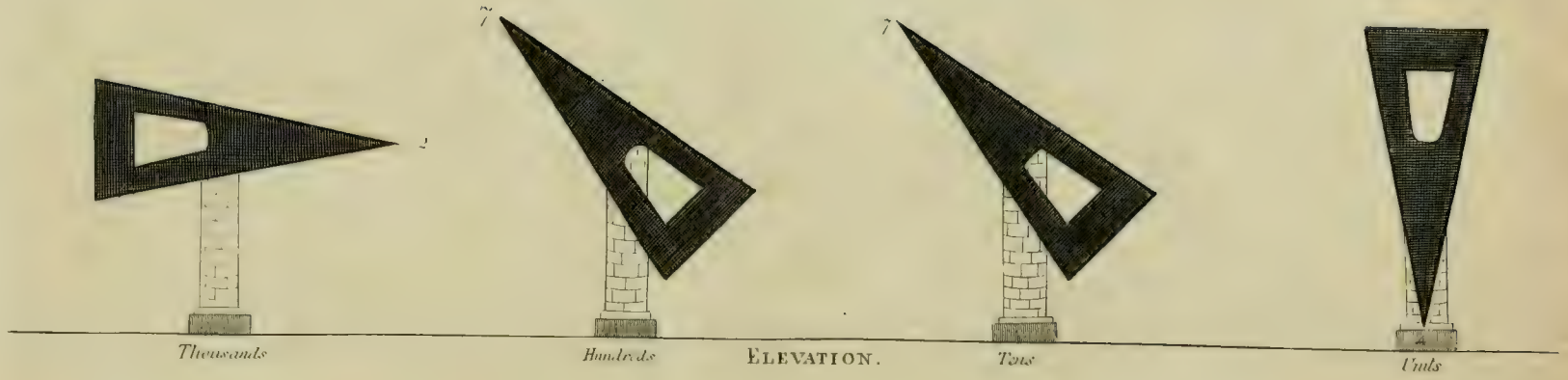
MODELS of the French Telegraph have been ſo often exhibited, and the machine itſelf is ſo well known, that it is not neceſſary to deſcribe it minutely in this place.—It is ſufficient to ſay that it conſiſts of a tall pole, with three moveable arms, which may be ſeen at a conſiderable diſtance through teleſcopes; theſe arms may be ſet in as many different poſitions as are requiſite to expreſs all the letters of the alphabet:—By a ſucceſſive combination of letters ſhewn in this manner words and ſentences are formed and intelligence communicated. No doubt can be made of the utility of this machine, as it has been applied to the moſt important purpoſes. It is obviouſly liable to miſtakes, from the number of changes requiſite for each word, and from the velocity with which it muſt be moved to convey intelligence with any tolerable expedition.

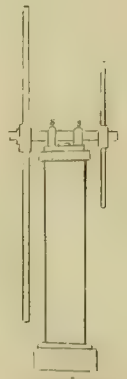
THE

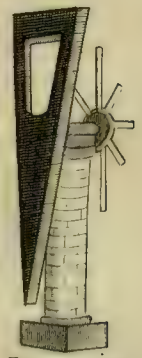
THE name, however, which is well choſen, has become ſo familiar, that I ſhall, with a ſlight alteration, adopt it for the apparatus which I am going to deſcribe. *Telegraph* is a proper name for a machine which deſcribes at a diſtance. *Telelograph*, or contractedly *Tellograph*, is a proper name for a machine that deſcribes *words* at a diſtance.

DOCTOR Hooke, to whom every mechanic philoſopher muſt recur, has written an eſſay upon the ſubject of conveying ſwift intelligence, in which he propoſes to uſe large wooden letters in ſucceſſion. The ſiege of Vienna turned his attention to the buſineſs. This method is more cumbrous than the French Telegraph, but far leſs liable to error.

I TRIED it before I had ſeen Hooke's work in the year 1767 in London, and I could diſtinctly read letters illuminated with lamps in Hamſtead church yard, from the houſe of Mr. Elers in Great Ruſſel-ſtreet, Bloomſbury, to whom I refer for the date and circumſtance—To him and to Mr. E. Delaval, F. R. S. to Mr. Perrot of Harehatch, and to Mr. Woulfe the chemiſt, I refer for the precedency, which I claim in this invention. In that year I invented the idea of my preſent Tellograph, propoſing to make uſe of wind-mill ſails inſtead of the hands or pointers, which I now employ. Mr. Perrot was ſo good as to accompany me more than once to a hill near his houſe to obſerve with a teleſcope the windmill at Nettlebed, which places are, I think, ſixteen




Section


Perspective

Scale of Fifty Feet

ſixteen miles aſunder. My intention at that time was to contrive not only a ſwift but an unſuſpected mode of intelligence: By means of common windmills this might have been effected, before an account of the French Telegraph was made public *.

My machinery conſiſts of four triangular pointers or hands, each of which points like the hands of a clock to different ſituations in the circles which they deſcribe.

It is eaſy to diſtinguiſh whether a hand moving vertically points perpendicularly downwards or upwards, horizontally to the right or left, or to any of the four intermediate ſituations.

The

* Since this paper was written, I received a letter from Mr. Perrot, which has been ſeen by the Preſident, containing the following paſſage:

" I perfectly recollect having ſeveral converſations with you in 1767, on the " ſubject of a ſpeedy and ſecret conveyance of intelligence; I recollect our going up " the hills to ſee how far, and how diſtinctly, the arms (and the poſition of them) " of Nettlebed windmill were to be diſcovered with eaſe. As to the experiments " from High-gate to London by means of lamps, I was not preſent at the time, " but I remember your mentioning the circumſtance to me, I believe in the ſame " year. All theſe particulars were brought very ſtrongly to my memory when the " French a few years ago conveyed intelligence by ſignals; and I then thought and " declared, that the merit of the invention undoubtedly belonged to you.—I am very " glad that I have it in my power to ſend you this confirmation, becauſe I imagine " there is no other perſon now living who can witneſs your obſervations in Berk- " ſhire.

The eye can eaſily perceive the eight different poſitions in which one of the pointers is repreſented, plate II. fig. 1. by turning the eye to the circle A.

A similar circle may be imagined round each of the pointers, by which the numbers which they are intended to expreſs may be diſcovered with much facility.

Of theſe eight poſitions ſeven only are employed to denote figures, the upright poſition of the hand or pointer being reſerved to repreſent O or Zero. The figures thus denoted refer to a vocabulary, in which all the words are numbered. Of the four pointers, plate I. that which appears to the left hand of the obſerver repreſents thouſands, the others hundreds, tens and units, in ſucceſſion, as in common numeration.

* In the annexed plate the four large pointers ſtand at 2774, which in the common arrangement of my vocabulary denotes the

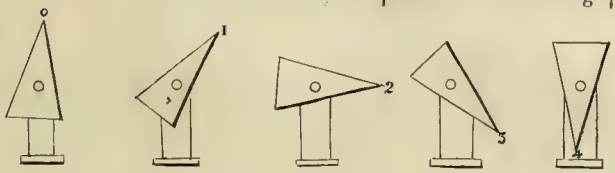
* I inſert, plate II, fig. 2, a line deſcribed by telegraphs as an example.—It is the firſt line of the following verſes written on the proſpect of correſponding between England and Ireland by the Telegraph:

Hark from Baſaltic rocks and giant walls,
To Britain's ſhores the glad Hibernia calls;
Her voice no longer waits retarding tides,
The meeting coaſts no more the ſea divides.
Quick, at the voice of fortune or of fame,
Kindles from ſhore to ſhore the patriot flame,
Hov'ring in air, each kindred genius ſmiles,
And binds with cloſer bands the ſiſter Iſles.

The numbers are, 2645, 2331, 573, 1113, 244, 2411, 6336.

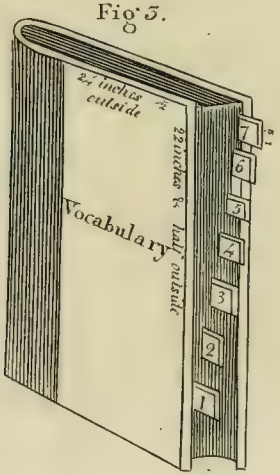
Fig1.

View of the 8 different positions of the Telloglapl



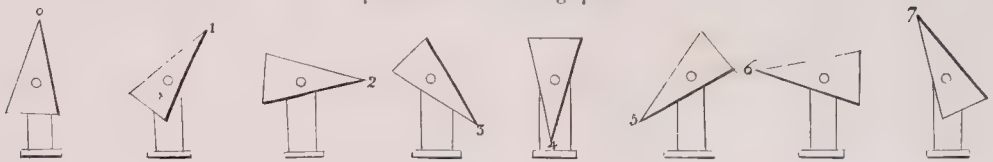
Example of a

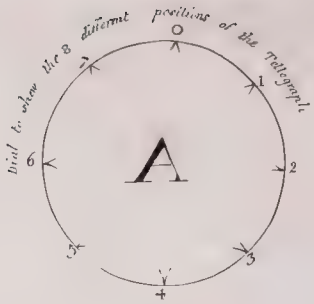
Fig 5.



Figl.

View of the 8 different positions of the Tellograph





Example of a line of Six words described by the Tellograph

Fig 3.

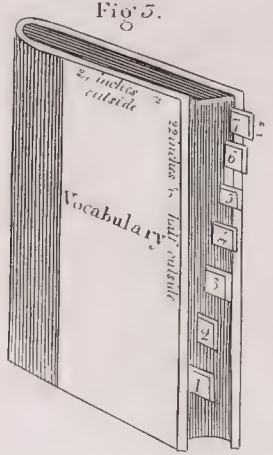
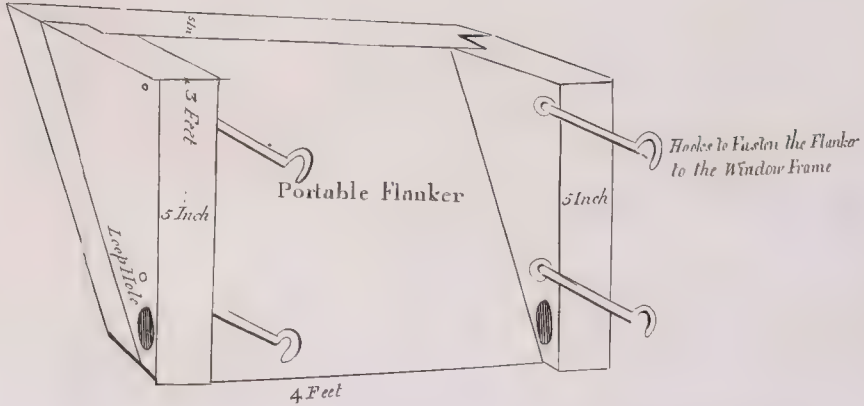
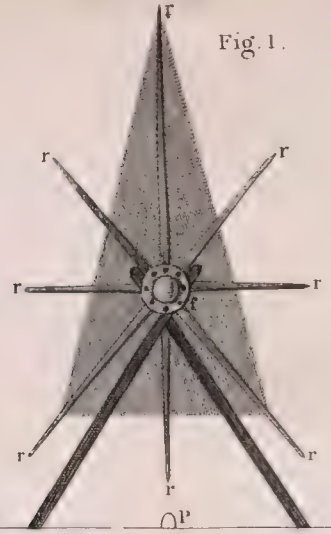


Fig. 4.



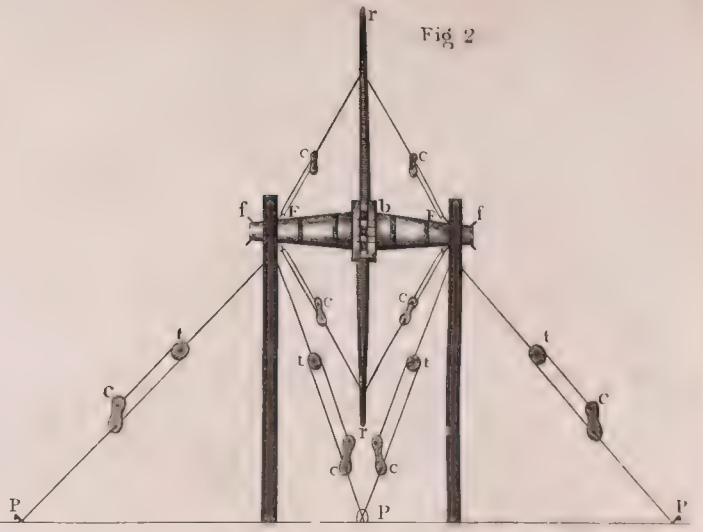
Front Elevation

Fig. 1.



Profile

Fig. 2

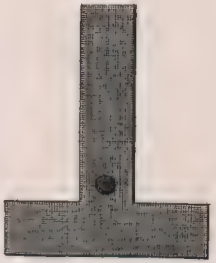


Stand

Fig. 3.

Axletree Fig. 4.

Fig. 5.



Index of a different Form

Fig. 6.
Holder

Fig. 7.

Flanch

Fig. 8

Index of a different Form

the Royal Iriſh Academy. For permanent ſtations, which may be ſeen clearly with tolerable glaſſes at twenty miles diſtance, ſtone or wooden pillars ſixteen or twenty feet high muſt be ſolidly erected; on the top of theſe a moveable circle or platform turns horizontally upon a centre:—on this platform an axis moves vertically and carries the arm or pointer along with it. Eight handles turn the pointers, which are fixed in their different poſitions by a catch or alidad. By means of the platform the pointer may be turned to any part of the compaſs, and as one ſide of it is painted black and the other white, either ſide may be employed, as the colour of the clouds or the ſituation of the place may require.

Besides theſe permanent machines, of which dimenſions and a deſcription are ſubjoined, Plate I. I make uſe of portable machines, (which may be detached like Tentacula from the main body in hazy weather) conſiſting of pointers ten or twelve feet high, and of a light triangular ſtand, which can be eaſily faſtened with tent pegs to the ground: Theſe may be lodged in any houſe near the place where they are uſed, or in times of danger may be carried back to the permanent ſtations every night.

In managing a correſpondence by theſe machines, it is neceſſary to have certain ſignals eſtabliſhed; nor are theſe ſignals merely arbitrary; it is abſolutely neceſſary that they ſhould be

made by the two external or by the two internal pointers, elſe they could not be repeated by the intermediate ſtations without confuſion, becauſe in the middle ſtations that pointer which repreſents thouſands, when conveying a meſſage eaſtward, for inſtance, muſt, when an anſwer is returned in an oppoſite direction, repreſent units; the ſame change will take place between the pointers that denote hundreds and tens.

CERTAIN hours of the day muſt be appointed for ordinary communication. Suppoſe ten o'clock in the morning and five in the afternoon in Summer. Every communication begins from the capital. If no intelligence is required to be conveyed from thence the word BEGIN is ſent to the country ſtation, which may then proceed or diſmiſs the meeting.

WHEN any communication is to be commenced, the pointers that denote thouſands and units are whirled round till the ſame is done at the correſponding ſtation. When this ſignal has been anſwered, the perſon who gave it proceeds to ſend his intelligence. As ſoon as he begins, the pointer of hundreds at the oppoſite ſtation is turned to Two, and kept in that poſition till the word is made out from the vocabulary; it is then turned up to O or ZERO. The perſon who is ſpeaking, when he perceives by this ſignal that he is underſtood, turns all the machines to NOUGHT, which is always to be done at the concluſion of every word.

When all his machines are in this poſition his correſpondent again turns his pointer belonging to the place of hundreds to Two, where it is to remain till he receives another word, and ſo on till all that is meant to be ſaid is finiſhed. To denote that his communication is finiſhed ‡ Thousands and Units are to be vibrated backwards and forwards, with the point downwards like a pendulum, till the ſame is done at the oppoſite ſtation.

If any interruption takes place on either ſide from a cloud, a ſhower or any accident, it is pointed out by vibrating Thousands and Units, with their points upwards, which ſignal muſt be repeated from the oppoſite ſtation. Whoever has made the ſignal of interruption muſt make a ſignal of recommencement, when he is ready to proceed, by vibrating Hundreds and Tens with their points upwards; when this is anſwered (but not before) the buſineſs may proceed. It ſhould be obſerved in general that every ſignal ſhould be anſwered.

It requires ſome ſteadineſs to abide by theſe ſignals, but if they are patiently adhered to the ſucceſs that they enſure will ſoon convince the operator of their utility. Without them every thing would be in confuſion; by their interpoſition perſpicuity and order are perfectly inſured.

‡ I uſe the words Thouſands and Units here and in the reſt of this deſcription for the pointers or machines that ſtand in the numerical place of thouſands and units.

In my firſt experiments the impatience of friends, who were preſent, was ſometimes ſo great as to make it very difficult to adhere to previous arrangements; but a very little practice (I mean the practice of five or ſix days) reduced the routine of communication to as much facility as could be deſired, ſo that a word (or a ſentence if contained in the vocabulary) could be ſent in twenty ſeconds.

Any perſon who has the ſlighteſt taſte for ſcience or literature muſt be ſtruck when he ſees inſtantaneous interpretation of ſignals, which are made at the diſtance of fifteen or twenty miles, and when he perceives the power which is obtained of tranſmitting thought with ſuch aſtoniſhing rapidity.

I shall not enter into a detail of the ſignals which are neceſſary for intermediate ſtations; it would take up ſome time to explain them, and they will readily occur from what has been ſaid already.

What I have hitherto deſcribed relates to a large and permanent eſtabliſhment†, for the management of which one man is required at each pointer, one at the teleſcope and another at the vocabulary; but for ordinary purpoſes a ſingle pointer with

† The Houſe belonging to this eſtabliſhment might be made tenable againſt a mob or muſketry at a ſmall expenſe by port-ſlankers of elm or aſh, adapted occaſionally to the windows. See Plate I. Fig. 4.

with one man to work it, and another at the teleſcope with a ſmaller vocabulary, are ſufficient. With this reduced apparatus we can with eaſe ſpeak at the rate of one word per minute to a great diſtance, as the time loſt by intermediate ſtations is but ſmall.

The vocabulary correſponding with the numbers denoted by this machinery is compoſed of a large book with mahogany covers, framed, to prevent them from warping. Its ſize is 47 inches by 21. It conſiſts of 49 double pages, that is to ſay, each ſheet is folded in the middle, where it opens from one page.

The book is divided into ſeven parts, conſiſting each of ſeven pages, by thin ſlips of mahogany, which ſerve to open it eaſily at each of theſe diviſions. Every one of theſe ſeven diviſions contains ſeven pages, and each page contains forty-nine words.

No more than forty-nine words are contained in a page, becauſe the numbers 8 and 9 and zero are omitted. This omiſſion ariſes from the ſtructure of the machinery, which points only to ſeven numbers, reſerving O for a point of reſt, at which point the hands indicate nothing. In every hundred therefore only forty-nine numbers are uſed; and in every thouſand only ſeven hundred is counted. Each diviſion of the book ſeparated by the mahogany rulers contains all the efficient numbers in ſeven hundred. Each of theſe rulers projects

(Plate

(Plate II. Fig. 3.) beyond the ſides of the pages, and each is numbered in ſucceſſion from one to ſeven, and they are ſo placed below one another as to permit the numbers on all of them to be ſeen at once, as in Plate I.

When any number of thouſands is pointed out it can by means of theſe rulers be immediately ſelected; the ſeries of ſeven pages, which one of theſe rulers opens, is cut like the alphabet of a ledger at the edge, in ſeven diviſions. By theſe means the page containing the hundred which is wanted is inſtantly found. In the page thus found the tens from ten to ſeventy incluſive are divided from each other ſo as to be inſtantly diſtinguiſhable, and the units under each diviſion are in like manner eaſily ſelected.

Plate III. is a ſpecimen of the firſt page of the vocabulary, and though it is but one-fifth of the real ſize it is ſufficiently diſtinct. It is divided into eight claſſes; all the claſſes are numbered downwards ſeriatim from 1 to 77, omitting cyphers or zero and eights and nines. When once the claſs required is aſcertained any number on the page can be found immediately:—As for inſtance, the reader will eaſily ſelect Claſs IV. Number 36, or Claſs VII. Number 77, and ſo of the reſt.

Nothing remains to be explained but the manner in which the claſs in each page is pointed out by the machinery. For this

this purpoſe, before the pointers are turned to any ſet of figures, the pointer that repreſents thouſands is turned to the claſs that is wanted; as ſoon as the correſpondent anſwers this ſignal THOUSANDS is returned to O, and inſtantly all the pointers are moved to the places which denote the figures required for any word or ſentence.

WHEN the claſs is thus aſcertained, an index, which ſlides on the mahogany cover of the book, is ſet to the column belonging to this claſs; the number of thouſands is then opened by the ruler as ſoon as it is read off by the teleſcope. The number of hundreds is opened by the pages where they are cut away, and the number of tens and units is ſeen on the page. As the pointers are moved in ſucceſſion from thouſands to units the different diviſions of the book can be opened as faſt as the pointers are moved. The order of this book might be reverſed with apparent advantage, by dividing the book into claſſes by the mahogany rulers, &c. but I prefer, for reaſons which it would be tedious to inſiſt upon, the arrangement which I have followed.

As ſecrecy is an object of the greateſt conſequence, I ſhall endeavour to point out, in a few words, the ſuperiority of this mode of communication over any alphabetical arrangement, not only in point of expedition but of concealment.

ALTHOUGH

Although the common alphabet may be varied at pleaſure, and any arbitrary ſigns may be employed to convey the powers of each letter, yet by certain rules any of theſe arrangements may be decyphered. Whoever ſees the movements of the French Telegraph (I mean of that which is commonly known as ſuch) may unfold the intelligence which it conveys by merely marking down the changes which he ſees, and putting them into the hands of a decypherer. The rules for decyphering depend upon the uſual arrangements of letters. In our language a ſingle letter muſt be *A* or *I*. The proportions which exiſt between words of one, two, three, and any greater number of letters, are claſſed in catalogues, and from theſe the monoſyllables of any cypher are eaſily obtained; and from the letters of theſe monoſyllables the letters of longer words are diſcovered. By ſimilar rules, ſome of which are very ingenious, and which depend upon the general philoſophy of language, any alphabetical cypher may be eaſily unfolded. But theſe rules, except a very few of them, are uſeleſs when we employ cyphers, which denote entire words. Here the moſt obvious means of diſcovery may be avoided, by omitting thoſe common words which occur ſo frequently in every language, *the*, *and*, *that*, *to*, *&c.* But ſuppoſing that from its frequent recurrence any particular word ſhould be diſcovered, no progreſs can be made from theſe data. The cypher of each word is an iſolated fact, which leads to nothing farther. Suppoſe the knowledge of any particular vocabulary ſhould fall into hands for which it was not intended, a ſlight change in the numeration, without any actual change of

of the figures, would entirely prevent diſcovery:—For inſtance, if the Lord Lieutenant wiſhed to ſend orders to the Commander in Chief, if he made uſe of the numbers written in the vocabulary on one day, he might, after previous communication, employ a different numeration, by ordering that 1 (for inſtance) ſhould be added to every figure. If claſs II. Number 3664, ſtood in the vocabulary for gunpowder, by the addition which I have propoſed the number would ſtand, Claſs III. Number 4775, which might mean a Crocodile or Tippo-Saib, or any thing foreign to the real word. By ſimilar proviſions any number of ſeparate correſpondents might carry on a mutual intercourſe without interfering with one another.

In the courſe of twelve months I tried a great number of experiments, and carried on a great number of converſations with the Tellograph; of all theſe a regular journal has been kept, containing what was unſucceſsful as well as what ſucceeded. If ſuch journals were kept in the proſecution of philoſophical purſuits, they would pay for the trouble of keeping them by the accuracy of the experience which they enſure.

I shall not at preſent enter into any detail of my nocturnal Tellograph. Its velocity far exceeds what can be done by day, as in clear weather ſtations at fifty miles diſtance may be plainly diſtinguiſhed.

When this Paper was firſt preſented to the Academy I had determined to try an experiment acroſs the channel from Donaghadee to Port Patrick. I was ambitious of being the firſt perſon who ſhould connect the iſlands more cloſely by facilitating their mutual intercourſe. Public buſineſs prevented me from going to the ſea ſide at the time I had intended, and prevented me from carrying on a ſeries of converſations by day and night between the two kingdoms; but Mr. Lovell Edgeworth, my ſon, had the ſatisfaction of ſending four meſſages acroſs the channel at four o'clock P. M. on the 24th of Auguſt 1795, and of receiving immediate anſwers, before a vaſt concourſe of people. The machines by which this communication was made were thirty feet high, and fifteen feet at the baſe. A child of four years could turn them. Miſty weather prevented them from being ſeen for two or three days; but when the weather cleared up a pointer of twelve feet high could have been plainly diſtinguiſhed acroſs the channel.

Though I have beſtowed much attention and labour upon this ſubject, I do not pretend to ſay that the means of Telegraphic communication which I have invented are the beſt that can be deviſed. Imitations without end may be attempted; pointers of various ſhapes and materials may be employed; real improvements will alſo probably be made, and perhaps new principles may be adopted. The varieties of art are infinite, and none but perſons of narrow underſtanding, who feel a want of reſources in their own invention, are jealous of competition and

diſpoſed

diſpoſed to monopoliſe diſcoveries. The thing itſelf muſt ſooner or later prevail, for utility convinces and governs mankind; and however inattention or timidity may for a time impede its progreſs, I will venture to predict that it will at ſome future period be generally practiſed, not only in theſe iſlands, but that it will in time become a means of communication between the moſt diſtant parts of the world, wherever arts and ſciences have civilized mankind.

ph.

Common Words. Clafs o.	W	Phrafes and Sentences. Clafs 7.	Hundred O.
1.		1.	
11 A	11	Attend to-day at A. M.	
12 Ab	12	——— at P. M.	
13 Ac	13	—— to-morrow at A. M.	
14 Ad	14	——— at P. M.	
15 Æ	15	—— to-night at ——	
16 Af	16	—— to-morrow night at ——	
17 Ag	17	—— on Monday at A. M.	
2.		2.	
21 Ah	21	——— at P. M.	
22 Ai	22	—— on Tuefday at A. M.	
23 Ak	23	——— at P. M.	
24 Al	24	—— on Wednefday at A. M.	
25 Am	25	——— at P. M.	
26 An	26	—— on Thurfday at A. M.	
27 Ap	27	——— at P. M.	
3.		3.	
31 Aq	31	—— on Friday at A. M.	
32 Ar	32	——— at P. M.	
33 As	33	—— on Saturday at A. M.	
34 At	34	——— at P. M.	
35 Av	35	Alarming intelligence is received	
36 Au	36	from ——	
37 Aw	37	Acquaint the Commiffioner's Officer at —	
4.		4.	
41 Ay	41	—— the principal Magiftrates at ——	
42 Ax	42	—— the H. Sheriff ——	
43 Az	43	—— the Secretary of War	
44 Abandon	44	——— of State	
45 Abufe	45	Agreeably to the orders of his	
46 Abhor	46	Majefty	
47 Abject	47	——— of the Ld. Lieutenant	
5.		5.	
51 Ability	51	——— of Government	
52 Able	52	—— of the Commanding Officer at —	
53 Above	53	—— of the Magiftrate of ——	
54 Abound	54	Agreeably to your orders	
55 About	55	All is well	
56 Abundance	56	Alter your Tellographs to black	
57 Abroad	57	——— to white	
6.		6.	
61 Abrupt	61	Admit no Strangers	
62 Abfent	62	Admiralty has iffued Orders	
63 Abfence	63	Admiralty has received Intelligence	
64 Abfolute	64	Arms have been found hidden at ——	
65 Abftain	65	An Army approaches, in number ——	
66 Abfurd	66	An armed Mob ———	
67 Abftain	67	Articles of Capitulation agreed to	
7.		7.	
71 Abufe	71	Affiftance is required at ——	
72 Accede	72	Appearances are againft ———	
73 Accept	73	Anfwer my laft to-morrow	
74 Acceptable	74	Arrived fince my laft at ———	
75 Accident	75	Arrived news from E. Indies	
76 Accompany	76	Arrived Mails from ———	
77 Accompliſh	77	Agreeable intelligence is received	

Specimen of the Vocabulary belonging to Mr. Edgworth's Tellograph.

Common Words. Class 0.	Words less common. Class 1.	Technical Terms, c.n.m. Class 2.	Persons. Class 3.	Offices. Class 4.	Places. Class 5.	Navy and Merchant Ships. Class 6.	Phrases and Sentences. Class 7.	Hundred O.
1.	1.	1.	1.	1.	1.	1.	1.	
11 A	11 Abaſe	11 Aback	11 Abbot	11 Academy of Inſcriptions	11 Abbeville	11 Atlas	11 Attend to-day at A. M.	
12 Ab	12 Abate	12 Abacus	12 Ackland	12 Academy of B.L. Paris	12 Aberdeen	12 Ajax	12 ——— at P. M.	
13 Ac	13 Abbey	13 Abaft	13 Acton	13 Academy	13 Abergavenny	13 Albion	13 —— to-morrow at A. M.	
14 Ad	14 Abbeſs	14 Abatis	14 Acheſon	14 Account Office	14 Abington	14 Africa	14 ——— at P. M.	
15 Æ	15 Abbot	15 Abdomen	15 Adams	15 Admiralty	15 Abidos	15 Audacious	15 ——— to-night at ——	
16 Af	16 Abdicate	16 Abductor	16 Adamſon	16 Agent to the —	16 Abyſſinia	16 Agamemnon	16 ——— to-morrow night at ——	
17 Ag	17 Abed Abet	17 Abeal	17 Adair	17 Admiral	17 Acadia	17 America	17 ——— on Monday at A. M.	
2.	2.	2.	2.	2.	2.	2.	2.	
21 Ah	21 Abide	21 Aberration	21 Adolphus	21 Adjutant	21 Acamboo	21 Anſon	21 ——— at P. M.	
22 Aı	22 Abjure	22 Abeyance	22 Addington	22 Alderman of Briſtol	22 Acapulca	22 Alcide	22 ——— on Tueſday at A. M.	
23 Ak	23 Ablative	23 Ablution	23 Ahmuty	23 Alderman of Cork	23 Acam	23 Alexander	23 ——— at P. M.	
24 Al	24 Ablebodied	24 Abortion	24 Aikin	24 Alderman of ——	24 Adda	24 Alfred	24 —— on Wedneſday at A. M.	
25 Am	25 Abolished	25 Abreaſt	25 Alcock	25 Archdeacon of ——	25 Adrianople	25 Arrogant	25 ——— at P. M.	
26 An	26 Abomination	26 Abrogation	26 Aldrige	26 — Ardagh	26 Ætna	26 Aſia	26 ——— on Thurſday at A. M.	
27 Ap	27 Abortive	27 Abceſs	27 Allot	27 — Ardfert	27 Africa	27 Ardent	27 ——— at P. M.	
3.	3.	3.	3.	3.	3.	3.	3.	
31 Aq	31 Above-all	31 Abeis	31 Alley	31 — Armagh	31 Agincourt	31 Achilles	31 ——— on Friday at A. M.	
32 Ar	32 Above board	32 Abcenthium	32 Allett	32 — Aconry	32 Aix la Chapelle	32 Adamant	32 ——— at P. M.	
33 As	33 Above-mentioned	33 Abſorbent	33 Allen	33 — Aghadoe	33 Albany	33 Aſſiſtance	33 ——— on Saturday at A. M.	
34 At	34 Abridge	34 Abſortion	34 Alder	34 — Clogher	34 Alcantara	34 Acteon	34 ——— at P. M.	
35 Av	35 Abridgement	35 Abſtergent	35 Alexander	35 — Clonfert	35 Aleppo	35 Argo	35 Alarming intelligence is received from ——	
36 Au	36 Abruptly	36 Acacia	36 Amyatt	36 — Cloyne	36 Alexandria	36 Artois		
37 Aw	37 Abſentee	37 Academic	37 Ambroſe	37 — Connor	37 Algiers	37 Aſſurance	37 Acquaint the Commiſſioner's Officer at —	
4.	4.	4.	4.	4.	4.	4.	4.	
41 Ay	41 Abſolve	41 Acantha	41 Anderſon	41 — Dublin	41 Alicant	41 Arethuſa	41 ——— the principal Magiſtrates at ——	
42 Ax	42 Abſolution	42 Accretion	42 Andoe	42 Archbiſhop of	42 Alps	42 Æolus	42 ——— the H. Sheriff ——	
43 Az	43 Abſorb	43 Acefcent	43 Addrews	43 — Dublin	43 Alface	43 Active	43 ——— the Secretary of War	
44 Abandon	44 Abſtract	44 Acetous	44 Angel	44 — Armagh	44 Antrim	44 Alarm	44 ——— of State	
45 Abuſe	45 Abſtruſe	45 Achromatic	45 Anger	45 — Caſhel	45 Aylſbury	45 Amazon	45 Agreeably to the orders of his Majeſty	
46 Abhor	46 Abſurdly	46 Acids	46 Anneſly	46 — Cork	46 Ayrſhire	46 Ambuſcade		
47 Abject	47 Abyſs	47 Acidity	47 Anneſdale	47 — Canterbury	47 Allfaints	47 Amphion	47 ——— of the Ld. Lieutenant	
5.	5.	5.	5.	5.	5.	5.	5.	
51 Ability	51 Academy	51 Acme	51 Antrim	51 — Tuam	51 Alnwick	51 Apollo	51 ——— of Government	
52 Able	52 Accelerate	52 Aconite	52 Anſon	52 — York	52 Aloft	52 Aſtrea	52 ——— of the Commanding Officer at —	
53 Above	53 Accent	53 Acouſtics	53 Anſtruther	53 Admiral of	53 Alersford	53 Alcmene	53 ——— of the Magiſtrate of ——	
54 Abound	54 Acceſs	54 Acroſtic	54 Antonie	54 — the Fleet	54 Aldborough	54 Andromache	54 Agreeably to your orders	
55 About	55 Acceſſory	55 Adamant	55 Anthony	55 — the White	55 Alencon	55 Albemarle	55 All is well	
56 Abundance	56 Acceſſible	56 Adder	56 Alfred	56 — ditto, 1	56 Andes	56 Aurora	56 Alter your Tellographs to black	
57 Abroad	57 Acclamation	57 Adder's-tongue	57 Alphonſus	57 — ditto, 2	57 Angleſey	57 Amphitrite	57 ——— to white	
6.	6.	6.	6.	6.	6.	6.	6.	
61 Abrupt	61 Accommodate	61 Adductor	61 Amadeus	61 — ditto, 3	61 Angola	61 Ariadne	61 Admit no Strangers	
62 Abſent	62 Accomplice	62 Adelphi	62 Anne	62 — ditto, 4	62 Anjou	62 Alfred	62 Admiralty has iſſued Orders	
63 Abſence	63 Accoſt	63 Ades	63 Anſolm	63 — ditto, 5	63 Anhalt	63 Atalanta	63 Admiralty has received Intelligence	
64 Abſolute	64 Accountant	64 Adit	64 Appleby	64 — ditto, 6	64 Antioch	64 Ariel	64 Arms have been found hidden at ——	
65 Abſtain	65 Account book	65 Adjutant	65 Apſley	65 — ditto, 7	65 Antwerp	65 Allegiance	65 An Army approaches, in number ——	
66 Abſurd	66 Accretion	66 Adnata	66 Archer	66 — ditto, 8	66 Archangel	66 Albany	66 An armed Mob ———	
67 Abſtain	67 Accrue	67 Adonis	67 Auſtin	67 — ditto, 9	67 Argenton	67 Alderney	67 Articles of Capitulation agreed to	
7.	7.	7.	7.	7.	7.	7.	7.	
71 Abuſe	71 Accumulate	71 Adoſcalation	71 Archdale	71 — ditto, 10	71 Atherſtone	71 Alert	71 Aſſiſtance is required at ——	
72 Accede	72 Accuſative	71 Adracanth	72 Arran, Ld.	72 — ditto, 11	72 Ardee	72 Alligator	72 Appearances are againſt ———	
73 Accept	73 Ace	73 Adrift	73 Archdall	73 Admiral of	73 Arklow	73 Avenger	73 Anſwer my laſt to-morrow	
74 Acceptable	74 Achieve	74 Advance ſoſſe	74 Aſhe	74 — the Blue	74 Armagh	74 Ætna	74 Arrived ſince my laſt at ———	
75 Accident	75 Acquiſition	75 Advance-guard	75 Atkinſon	75 — ditto, 1	75 Athenry	75 Alecto	75 Arrived news from E. Indies	
76 Accompany	76 Acquittance	76 Advancement	76 Aylward	76 — ditto, 2	76 Athlone	76 Aquilone	76 Arrived Mails from ———	
77 Accompliſh	77 Acre	77 Advertiſement	77 Ayre	77 — ditto, 3	77 Athy	77 Argus	77 Agreeable intelligence is received	

Of the COMPOSITION *and* PROPORTION *of* CARBON *in* BITUMENS *and* MINERAL COAL. *By* RICHARD KIRWAN, *Eſq*; *L.L.D. F.R.S. and M.R.I.A.*

Read December 19th, 1795.

AN exact knowledge of the component parts of the different ſpecies of mineral coal, and alſo of bitumens (ſubſtances which moſt of them contain;) forms an object of ſome importance not only to the naturaliſt, whoſe views are merely ſpeculative, but to the practical œconomiſt, who wiſhes to extract from each ſpecies all the advantages it is capable of yielding, and to be enabled to compare the various kinds afforded by different countries, in order to obtain and employ that which ſhall on the compariſon appear to him beſt ſuited to his intentions.

IN effect coals are not only applicable to the more uſual purpoſes of combuſtion, an uſe, ſimple as it may appear, attended according to their various ſpecies with a conſiderable difference of calefactive power both in intenſity and duration, but alſo to the production of varniſhes, much more advantageouſly applicable in many inſtances than thoſe extracted from the vegetable kingdom,

dom, as Lord Dundonald has diſcovered and abundantly proved †, and alſo of that chared reſiduum called *Coak*, the only one that can be reſorted to in many caſes, and in moſt ſuperior to vegetable charcoal.

Coals and bitumens are however ſubſtances that reſiſt the uſual modes of analyſis; they elude the action of aqueous, acid, alkaline or ſpirituous menſtruums; and diſtillation, the only mode hitherto uſed, confounds and varies their natural contents.

Reflecting on theſe obſtacles to an exact diſcrimination of bitumens and coals, and of the various kinds of theſe laſt, it occurred to me that partly by combuſtion, and partly by their efficacy in decompoſing nitre, the ſecret of their internal compoſition might poſſibly be unveiled.

1°. *Combuſtion.* I have obſerved that all the ſpecies of ſolid bitumen, properly ſo called, when laid on a red hot iron, burn with a large bright flame, ſmoke and ſoot, leaving none or ſcarce any coaly reſiduum, and only a little aſhes.

That the ſofter bitumens, as maltha, burn in the ſame manner, leaving no coal, but only a little aſhes, and requiring no increaſe of heat for their intire conſumption.

That

† Upon the moſt minute enquiry why coal varniſh is not more commonly employed in paying the bottoms of ſhips, I have been informed the principal reaſon is, that it ſucceeds *too well*—The ſhips not requiring ſuch frequent repair.

That *aſphalt* burns with flame and ſoot, but melts and ſwells, and requires for its intire conſumption an increaſe of heat, leaving ſcarce any coal, and but little aſhes.

It is moreover well known that liquid bitumens contain inflammable air and carbon. That they abſorb atmoſpheric air when long expoſed to it and light. That in conſequence of this abſorbtion they are thickened, blackened and condenſed, firſt into mineral tar, then into mineral pitch or maltha, and laſtly into aſphalt. That almoſt all ſpecies of mineral coal yield more or leſs of both ſpecies of bitumen on diſtillation, leaving a ſhining coaly reſiduum, but that the proportion is variable in every ſpecies, according to the degree of heat applied; that the reſiduum always obſtinately retains a proportion of bitumen, and that conſequently diſtillation, in addition to its other imperfections, is an inſufficient medium whereby to diſcern the proportion of carbon and bitumen, and conſequently to diſcriminate the various ſorts of mineral coal from each other.

2°. *Decompoſition of nitre.* It has long ago been remarked by the juſtly celebrated Macquer† that nitre detonnates with no oily inflammable matter until ſuch matter is reduced to a coal, and then only in proportion to the carbonaceous matter it contains; an obſervation the truth of which will fully appear in the ſubſequent experiments. Hence it occurred to me that ſince in the

† 1 Diction. Chym. 2d Edition, p. 481.

the act of detonnation nitre is always totally or partially decompoſed; and ſince where carbonaceous compounds are employed this decompoſition ariſes ſolely from the mere carbonaceous part, and every thing elſe being equal, is proportioned to the quantity of mere carbon they contain; and ſince moſt ſpecies of coals are compounds of mere carbon and bitumen, as appears by the products of their diſtillation, it ſhould follow, that by the decompoſition of nitre the quantity of mere carbon in a given quantity of every ſpecies of coal may be diſcovered, and this being known, that of bitumen may be inferred, and the other uneſſential ingredients being detected by incineration, the whole contents of coaly ſubſtances might be aſcertained.

The compoſition of bitumens alſo, as far as relates to their proportion of carbon and oil, may be evidenced in the ſame manner: And here it is to be obſerved that the bitumens I here conſider are thoſe that are found in a dry or ſolid ſtate, and that theſe contain a larger proportion of carbon than the liquid bitumens; for though theſe laſt alſo contain carbon, it being an eſſential component part of all oils, yet this portion does not extricate or educe any air from nitre, nor conſequently contribute to its decompoſition, as the ſubſequent experiments ſufficiently evince, but is conſumed partly by the pure air ſpontaneouſly emitted by nitre during its ignition, and partly by the ambient atmoſphaeric air. Nay, when mineral coal is employed in the decompoſition of nitre, the ſhare which the mere carbonaceous part of the bitumen contained in it contributes to the decompoſition will be found ſo ſmall that it merits no conſideration in the general account.

The

The firſt ſtep towards carrying this analytic plan into execution muſt therefore be to determine the quantity of pure carbon neceſſary to decompoſe a given quantity of pure nitre. But here many practical difficulties occur which ſhall preſently be mentioned; the moſt perfect method of obviating them was that employed by the ever memorable Lavoiſier: He mixed the pureſt nitre with charcoal alſo purged of the inflammable as well as other airs and water which it uſually abſorbs, in the proportion which, after ſeveral trials, he found requiſite for the entire decompoſition of that ſalt, rammed them into a copper tube, fired them, and continued the inflammation under water, by which means the charcoal was acted on ſolely by the air educed from the nitre, to the intire excluſion of the external air, and this air was educed, ſolely by the ignited charcoal, to the entire excluſion of external heat, advantages that cannot be procured by the uſual mode of effecting this decompoſition; thus he found the proportion of charcoal neceſſary for the entire decompoſition of nitre to be as 1 to 7,57, or in other words, that 13,21 parts charcoal decompoſe 100 of nitre *, and yet even in this experiment I find a ſmall inaccuracy, as he did not take the water employed in mixing the nitre and charcoal into the account, and hence, and for ſome other reaſons, the detail of which would lead me too far, I think the proportion ſhould be as 1 to 7,868 nearly, or that 12,709 charcoal decompoſe 100 of nitre; but the difference is of little importance.

* 11 Mem. Scav. Etrang. p. 626.

This mode of experimenting however is inapplicable on the preſent occaſion, the different ſpecies of mineral coal being not ſo readily inflammable as to carry on the combuſtion in this manner. Hence I contented myſelf with the common manner, only uſing ſuch precautions as to render its reſults tolerably uniform, and repeating each experiment ſeveral times.

I examined the purity of the nitre I employed by nitrated ſilver, and found by the quantity of ſalited ſilver produced that 480 grains of the nitre contained 3,5 grains of common ſalt, 135 grains of muriated ſilver indicating 100 of common ſalt; hence the conſtant quantity of nitre I uſed was 483 5 grains, except in the experiments on bitumens, as I had not enough of them to expend on ſo large a quantity of nitre.

The nitre was heated barely to redneſs before any coal was projected on it in a wind furnace and a very large crucible; on this uniform degree of heat much of the uniformity of different experiments on the ſame ſpecies of coal depends.

In my firſt experiments the coals were reduced to a very fine powder, and then projected on the ignited nitre, but I obſerved that by this method much more of each ſpecies of coal was requiſite to alkalize the ſtandard quantity of nitre than when it was reduced to a coarſe powder, about the ſize of a pin's head or ſomewhat larger, and the reaſon is, that by the force of the exploſion much of the finer powder is carried off without having been

been in contact with the nitre. Hence in the experiments of Mr. Hielm, on the quantities of charcoal of different woods requiſite to alkalize 100 parts of nitre, we find theſe quantities to bear for the moſt part ſome analogy to their ſpecific gravities, being generally ſmaller when the ſpecific gravity of the charcoal is lighter.

Thus, ‡

	Specific Gravity.	Grains requiſite to alkalize 100 Grains of Nitre. First Experiment.	Second Experiment.
Oak coal	0,332	35	30
Birch coal	0,542	22	22
Pine coal	0,280	29	20
Fir coal	0,441	33	25
Coak	0,744	19	

Another circumſtance of great importance towards procuring juſt and uniform reſults is, that the projections of coal ſhould ſucceed each other without delay as ſoon as the flame ceaſes, for as ignited nitre gives out pure air ſpontaneouſly, and ſo much the more as it is more heated, the acid will be decompoſed and the nitre alkalized by a quantity of coal ſo much the ſmaller as the intervals of projection are longer. From inattention perhaps to this and the laſt mentioned particular, as well as from various conditions of common charcoal, which ſeldom contains leſs than $\frac{1}{12}$ and often $\frac{1}{8}$ of its weight of moiſture and abſorbed air, pro-

 ceeded

‡ Schwed. Abhandl. 1781. p. 188.

ceeded the various reſults of different chymiſts with reſpect to the proportion of it neceſſary to alkalize nitre.

It is almoſt ſuperfluous to add that the charcoal ſhould be projected in very ſmall portions. I ſeldom projected more than one or two grains at a time; each operation laſted from twenty to twenty-five minutes nearly. There is always ſome portion of nitre undecompoſed being protected by the ſurrounding alkali; this error is unavoidable but very ſmall. Even the poſition of the crucible in the furnace is not indifferent, for if it be near the flue more coal muſt be employed, which I attribute to the torrent of air which in that caſe affects it and carries away more than when the crucible is nearer to the anterior part of the furnace.

It may perhaps be ſuſpected that this and ſome other incidental errors may be avoided by previouſly mixing the nitre and coal, and projecting the mixture in ſmall portions into a red hot crucible; but not to mention that this method ſuppoſes the due proportion of theſe two ſubſtances to be known, which cannot be known till after the experiment, and alſo that every atom of theſe ſubſtances is in perfect contact with the other ſubſtance, elſe they cannot act on each other; independently, I ſay, of theſe unfounded ſuppoſitions, this mode of experimenting is ſtill more fallacious than the former, as, during theſe projections, a conſiderable proportion of the nitre is ſcattered and diſperſed, and may

may be ſeen adhering to the ſides of the crucible. This loſs being repeated at every projection becomes at laſt intolerable.

I now proceed to relate the experiments themſelves, conducted in the manner I have mentioned. The different ſpecies of coal and bitumen whoſe compoſition I have thus examined were Kilkenny coal, Maltha, Aſphalt, Lancaſhire, Cannel, Slaty Scotch Cannel, Whitehaven, Wigan, Swanſey and Leitrim, ſelecting of each ſort the pureſt ſpecimens, free from pyrites and viſible ſtony matter.

Kilkenny Coal.

Its colour is *black*, and when freſh broken frequently *violet*.

Its luſtre 4. metallic. Tranſparency 0.

Its fracture foliated, the courſe of the lamellæ variouſly and confuſedly directed.

Its fragments rather ſharp, and often diſcovering between the diſtinct concretions whitiſh illinitions.

Its hardneſs 7. Specific gravity 1,526.

Does not burn until wholly ignited, and then ſlowly conſumes without caking or emitting flame or ſmoke. 266 grains of it expoſed to a heat of 27° of Wedgwood in a crucible for five hours

hours did not loſe their luſtre until almoſt $\frac{9}{10}$ of them had diſappeared, and at laſt left reddiſh aſhes amounting to 7,13 grains, nearly 2,7 per cent. Projecting this coal in fine powder on 480 grains of pure ignited nitre, I found the ſalt required 65 grains of the coal to alkalize it, but only 50 grains when in coarſe powder; and in a third experiment, when the crucible was farther from the flue of the furnace, only 49 grains: ſo that I look upon 50 grains as being in round numbers neareſt to the truth. That is the proportion of one part of Kilkenny coal to 9 6 of nitre, or 100 parts of nitre require for their decompoſition 10,416 of Kilkenny coal.

This proportion of coal is much ſmaller than that of charcoal in Mr. Lavoiſier's experiment, which we have ſeen to be as 1 to 7,57, or as 13,21 to 100, which I attribute to the advantageous mode in which his experiment was inſtituted, as already explained; whereas in mine and the uſual way, the decompoſition of nitre is promoted by the external heat applied, as well as by the coal, and conſequently leſs of coal is employed.

From the experiments of Scheele one *might* be led to infer that the proportions of charcoal and nitre neceſſary to the alkalization of this latter approach ſtill nearer to each other than in Lavoiſier's ſtatement, and conſequently much nearer than in mine; for in his eſſay on plombago he tells us that five parts nitre are *ſufficient* to conſume one of charcoal, and conſequently it ſhould ſeem that one part charcoal ſhould decompoſe no more than five of

of nitre; the conſequence however is not juſt, for undoubtedly five parts nitre would conſume one of charcoal, but it does not thence follow that they would not conſume ſtill more. On the other hand he found that ten parts nitre were *neceſſary* for the conſumption of one part of plombago, whence it follows that one part of plombago decompoſes ten of nitre, otherwiſe nine parts nitre would ſuffice to conſume it, and the tenth would have been unneceſſary, as it acts only as it is decompoſed. Now this proportion approaches very nearly to my reſult, namely, 1 of charcoal to 9,6 of nitre.

Hence, and ſince Kilkenny coal in the preceding experiments ſhewed no ſign of its containing any thing bituminous, I take it for granted that it conſiſts almoſt entirely of pure carbon; and ſince 50 grains of it alkalize 480 grains of pure ignited nitre, that in all the ſubſequent experiments on other ſpecies of coals or bitumens free from ſulphur and iron, the decompoſition of this ſtandard quantity of nitre will indicate in the quantity of coal neceſſary for that decompoſition, the preſence of 50 parts of mere carbon.

Before I proceed to the recital of other experiments I muſt mention another circumſtance that occurs in making them, which is, that after the inflammation ceaſes a hiſſing noiſe is perceived for a long time, and is increaſed on adding freſh quantities of coal, even when the nitre is ſeemingly decompoſed; this ſeemed to

to me to ariſe from the decompoſition of the nitrous air or mephitized nitrous acid, of which a portion is always retained by the alkali, and conſequently I paid no attention to it, but always ceaſed adding coal when the inflammation totally ceaſed.

Maltha.

Its colour is dark brown or black.

Its luſtre 0. Tranſparency 0.

Its fracture, *uneven*, tough. Specific gravity 2,070.

It feels ſomewhat greaſy, yields to compreſſion, has a heavy ſmell, acquires a poliſh when ſcraped, does not adhere to the tongue or ſtain the fingers; its flame high and bright, leaving no coal, but only a little aſhes.

Having but a ſmall quantity of this ſubſtance, I on this occaſion uſed only 240 grains of nitre. When it was heated to redneſs I threw on it one grain of *vegetable* pitch; it immediately inflamed, but floated quietly on the ſurface of the nitre, and decrepitated like common ſalt, from the moiſture it contained. The flame was partly *white*, from the action of the air ſpontaneouſly emitted by the nitre, and partly *yellowiſh*, from the action of the ambient atmoſpheric air, but ſteady and unattended with thoſe turbulent guſhes that attend the decompoſition of nitre by carbonaceous ſubſtances.

I then

I THEN gradually projected on it 55 grains of maltha, which was all I had; this burned juſt as the pitch, but was attended with a blacker ſmoak, yet the nitre was ſo far from being alkalized that to produce this effect I was obliged to throw on it 29 grains of Cannel coal. Now 33,5 grains of Cannel coal, if it alone had been uſed, would ſuffice to alkalize 240 grains of nitre, as will preſently be ſeen, therefore the 55 grains of maltha and the one grain of pitch contained no more carbon than 33,5—29=4,5 grains; therefore 100 grains of maltha contain no more than 8 grains of carbon. And as theſe 8 grains of carbon provoked no turbulent eruption of air from the nitre, it is plain they did not contribute to its decompoſition, but were taken up by the air it ſpontaneouſly emitted, and partly by the ambient atmoſpheric air.

Of Aſphalt.

ITS colour is greyiſh black.

ITS luſtre 2.3. greaſy. Tranſparency 0.

ITS fracture perfectly conchoidal.

ITS hardneſs from 7 to 8, very brittle. Specific gravity from 1,07 to 1,165 by my trials. It feels ſmooth, but not greaſy; has no ſmell, except while pounding; does not ſtain the fingers; when heated it melts, ſwells and at laſt inflames, but it requires

for inflammation a higher heat than maltha does, and leaves no coal and ſcarce any aſhes.

Of this bitumen I found 161 grains requiſite to alkalize the ſtandard quantity of nitre. It viſibly educed air from the nitre, for there were eruptions from time to time, I ſuppoſe when the more oily part was conſumed and the carbonaccous laid bare; much of the flame was alſo yellowiſh. Hence 161 grains of aſphalt contain only 50 of mere carbon—that is nearly 31 per cent.

Mr. Thory, burning it in a low heat, found it to leave about $\frac{1}{7}$ of its weight of coal, after melting, ſwelling and inflaming as uſual*; however his aſphalt was not perfectly pure, as he obtained ſulphur from it.

Cannel Coal.

Its colour is black.

Its luſtre common 2. when freſh broken often barely 1. Tranſparency 0.

Its croſs fracture conchoidal. Fragments rather ſharp.

Its hardneſs from 7 to 8. Specific gravity by my trials 1,232. Per Doctor Watſon's 1,273. Does not ſtain the fingers; eaſily kindles

* 6 Crell's Chy. Journ. p. 62.

kindles without melting, and burns with a large bright flame, but of ſhort duration, leaving a large coaly reſiduum; does not cake. 240 grains of it heated until all the coaly part was conſumed left 7,5 grains of reddiſh brown aſhes, moſtly argillaceous, that is 3,12 per cent. 66.5 grains of it were ſufficient to alkalize the ſtandard quantity of nitre. It burned with a large bright flame, except the laſt portion, which was yellowiſh, the pure air of the nitre being then exhauſted. Hence 66,5 grains contained 50 of pure carbon and 2,08 of aſhes; then deducting 52,08 from 66,5 we find the quantity of bitumen equal 14,42; then 100 parts of it contain 75,2 of carbon, 21,68 bitumen of the ſort called maltha, and 3,1 of aſhes.

I TAKE this bitumen to be *maltha* from its quick inflammability and the ſhort duration and brightneſs of its flame, both which properties indicate the moſt inflammable of the bitumens, and whoſe flame is leaſt durable, from its refuſal to cake (caking being a property ariſing from the fuſion of aſphalt) and the difficult combuſtibility of the carbonaceous ſubſtance that remains after the ceſſation of its flame, qualities that counter-indicate *aſphalt*.

Slaty Cannel Coal.

THAT which I employed was from Ayrſhire in Scotland, the only one of this ſort imported to Dublin.

ITS colour is black.

Its luſtre 2. common. Tranſparency 0.

Its fracture partly ſlaty, partly imperfectly conchoidal. Fragments ſharp.

Its hardneſs from 5 to 8. Specific gravity 1,426 by my trials.

It burns like the compact Cannel, but ceaſes ſooner to flame. Does not cake; leaves a ſtony reſiduum. 240 grains of it treated as before mentioned leave 50 of reddiſh grey aſhes, equal 20,83 per cent. From the ſmell that iſſues from it during ignition I am led to think it contains ſome portion of ſulphur.

To alkalize 480 grains of nitre 105 grains of this coal were employed. It burned like the former with a large white continued flame, except the laſt portions. Hence this quantity contained 50 grains of mere carbon; and ſince it alſo contained 20,83 of aſhes, the remainder, viz. 34,15, muſt have been bitumen. Then 100 parts of it contain 47,62 of carbon, 32,52 of bitumen, and about 20 of aſhes. Some deduction however from theſe quantities of carbon and bitumen may be made by reaſon of the ſmall proportion of ſulphur contained in it. This bitumen I take to be maltha and not aſphalt, for the reaſons I mentioned in treating of compact Cannel.

It is from a coal of this ſort that Lord Dundonald extracts his tar, as maltha eaſily diſtills; but it is probably of a better kind, as this ſtony kind exiſts moſtly in Ayrſhire.

By

By his Lordſhip's mode of diſtillation however much ſeems to be loſt during the internal combuſtion. I ſhould think the Prince of Naſſau Saarbruck's method in this reſpect more advantageous. Mr. Sage tells us that by diſtillation he obtained from Cannel coal $\frac{1}{3}$ of its weight of tar †; but Mr. Faujas, who uſes Lord Dundonald's method, obtains from the coal of Deciſe, which ſeems to be of this kind, only 4 per cent. of tar*. Faujas alſo obſerved that this tar is gradually converted into aſphalt by long expoſure to the air, which confirms the difference I have eſtabliſhed between the two bitumens.

Whitehaven Coal.

Its colour is black.

Its luſtre 3. greaſy. Tranſparency 0.

Its fracture plane foliated. Its fragments 2. often diſcovering quadrangular or cubic diſtinct concretions, ſometimes interſected with browniſh red flakes.

Its hardneſs 6. very brittle. Specific gravity 1,257 by my trials. Stains the fingers, particularly when moiſt.

It burns at firſt with a clear flame, and for a long time, but at laſt cakes. 240 grains of it after five hours ſtrong heat left only 4 grains of a reddiſh aſhes, or about 1,7 per cent.

The

† 35 Roz. Jour. p. 387. 27 Roz. Jour. p. 188.

The ſtandard quantity of nitre was alkalized by 88 grains of this coal. Hence 100 grains of it contain nearly 57 of mere carbon, 41,3 of a mixture of maltha and aſphalt, and 1,7 of aſhes. That it contains both maltha and aſphalt is evident from its flame and caking. The proportion I cannot exactly aſcertain, but moſt probably the aſphalt predominates.

Wigan Coal.

Its colour is black.

Its luſtre 3. greaſy. Tranſparency 0.

Its fracture plane foliated. The lamellæ, ſome uniformly ſome promiſcuouſly directed. In the groſs often flaty. Forms ſeparate concretions, often with bright yellowiſh illinitions.

Its hardneſs 6. Specific gravity 1,268 by my trials.

It burns with a bright flame, and quicker than the foregoing, and is leſs apt to cake. 328 grains of it expoſed as the former to a ſtrong heat left 5,13 grains of aſhes, that is 1,57 per cent. 81 grains of it decompoſed 480 grains of nitre. Hence 100 grains of it contain 61,73 of carbon, 36,7 of a mixture of maltha and aſphalt, and 1,57 of aſhes.

It ſeems to contain a larger proportion of maltha with reſpect to its quantity of aſphalt than Whitehaven coal does.

Swanſey

Swanſey Coal.

Its colour is black.

Its luſtre 2. Tranſparency 0.

Its fracture foliated, but ſome lamellæ being at right angles with the other give it a fibrous or ſtriated appearance. Fragments 2.

Its hardneſs 5. very brittle. Specific gravity 1,357 by my trials.

It burns more ſlowly than the former and cakes.

240 grains of it treated as the former kinds left 8 grains of yellowiſh red aſhes; that is equal 3,33 per cent.

Of this coal 68 grains were requiſite to decompoſe 480 grains of nitre. Then 100 grains of it contain 73,53 of carbon, 23,14 of a mixture of maltha and aſphalt, and 3,33 of aſhes. The aſphalt ſeems to predominate.

Leitrim Coal.

Its colour is black.

Its luſtre when freſh broken 3. Tranſparency 0.

Its fracture foliated. Its fragments 2.

Its

Its hardneſs 6. very brittle. Specific gravity 1,351 by my trials. It ſlightly cakes.

240 grains of it left after three hours expoſure to heat 12,5 grains of reddiſh grey aſhes, that is equal 5,2 per cent.

The decompoſition of the ſtandard quantity of nitre required 70 grains of this coal. Hence 100 grains of it contain 71,43 of carbon, 23,37 of a mixture of maltha and aſphalt, and 5,2 of aſhes.

Newcaſtle Coal.

I had none of this kind of coal, but according to Doctor Watſon's experiment it left on diſtillation a coaly reſiduum amounting to 58 per cent. and hence contained about 40 of a mixture of aſphalt and maltha, in which the former appears to prædominate. Hence it much reſembles the Whitehaven coal, but it evidently contains ſulphur alſo, which that of Whitehaven ſeldom does.

A Synoptical

A Synoptical View of the Contents of Bitumens and different Sorts of Mineral Coal.

100 Parts	Carbon.	Bitumen.	Aſhes.	Specific Gravity.
Maltha - -	8	—	—	2,070
Aſphalt -	31	68	—	1,117
Kilkenny - -	97,3	—	3,7	1,526
Compact Cannel -	75,2	21,68 Maltha	3,1	1,232
Slaty Cannel -	47,62	32,52 Maltha	20	1,426
Whitehaven -	57	41,3 mixt	1,7	1,257
Wigan - -	61,73	36,7 mixt	1,57	1,268
Swanſey - -	73,53	23,14 mixt	3,33	1,357
Leitrim - -	71,43	23,37 mixt	5,20	1,351
Newcaſtle -	58	40 mixt	—	1,271

To theſe reſults I ſhall add a few more, taken from a treatiſe on pit coal lately publiſhed by Signior Fabroni. The Italian coals were examined by himſelf; the French and German by other chymiſts. All by diſtillation.

100 Parts	Carbon.	Bitumen.	Aſhes.	Specific Gravity.
Coal of Halles -	86	12	—	—
of Tudertino -	25	75	—	—
of Cortolla -	45	43	12	1,403
of Macinaia -	60	37	3	1,411
Stony of do. -	12,5	37,5	50	1,666
of Mocaio -	32	35	33	1,403

THESE coals contain very little aſphalt, but chiefly maltha.

MOST coals afford a volatile alkali by diſtillation; this ſeems to me to be rather a product of the operation ariſing from the union of hydrogen and mephitic air, and thus the alkaline baſis of the ammoniacs found on volcanos ſeem to have been formed. Coals alſo afford an acid, commonly the marine, or if pyritous, alſo the vitriolic, more rarely the ſuccinous.

ACCORDING to Mr. Jars, 100 parts of the beſt Engliſh coal give when chared 63 of *coaks**, but Hielm found the reſiduum of

* 1 Jars, p. 329.

of the beſt Engliſh coals diſtilled to amount to 73 per cent; and Doctor Watſon found the reſiduum of Newcaſtle coal to amount only to 58 per cent. Theſe reſults neceſſarily differ according to the degree of heat applied, the duration of the combuſtion and the variable admiſſion of air. It is plain the bitumen is never totally expelled, at leaſt not until moſt of the carbon is conſumed; but much more of it is expelled by combuſtion than by diſtillation. 3 Watſon, p. 27 and 28.

By Lavoiſier's experiments it appears that equal quantities of water under equal ſurfaces are evaporated, and conſequently equal heats produced by*.

By 403lbs. of coaks		By 17 of coaks
600lbs. of pit coal		10 of pit coal
600lbs. of charcoal	or in meaſure	40 of charcoal
1089lbs. of oak		33 of oak.

The ſame ſuperiority of coaks over charcoal has alſo been obſerved in Germany in other caſes, though with variations in the reſults, plainly ariſing from the different degrees of carbonification. Thus in Sileſia it was found that in ſmelting of iron ore 92lbs. or one meaſure of coaks was equal to 180lbs. or 3 meaſures

* Mem. Stock. 1781. p. 187.

ſures of charcoal *. Elſewhere it was remarked that one meaſure of coaks were equivalent to 5 of charcoal and 3 of pit coal ‡. Doubtleſs according to the quality of this laſt.

The cauſes of theſe differences deſerve attention, as the contrary might be preſumed. For in the firſt place I have ſtated that the carbonic part of pit coal is exactly the ſame as common charcoal, and therefore when equal weights of both are employed it ſhould be expected that the calorific effects of both ſhould coincide. In the next place it is known that pit coal and woods containing a large proportion of oil muſt contain a large proportion of inflammable air, and this in combuſtion gives out more heat than an equal weight of mere carbon in the proportion of 3 to 1 †. Therefore it ſhould ſeem that a ſmall quantity of wood ſhould produce the ſame calorific effect as a larger of charcoal.

To remove theſe difficulties I ſhall lay down two poſitions: 1ſt, That the quantity of heat given out by carbon is to that given out by an equal weight of inflammable air (or hydrogen as it is now called) as 1 to 3.

2dly, That to communicate equal quantities of heat, in the caſe now before us, atmoſpheric air muſt have taken up either equal quantities of mere carbon or a quantity of inflammable air equal to one-third of the deficiency.

Now

* 1 Bergm. Jour. 1790. p. 320. ‡ 1 Bergm. Jour. 1792. p. 60.

† 1 Chy. Lavois. p. 104.

Now on examination it will be found that there is ſufficient reaſon to think that this equality or compenſation took place in every inſtance.

Thus, comparing *coaks* and *charcoal*, we muſt obſerve that, according to Doctor Watſon's experiments, charcoal gains 9 per cent. by expoſure to the air for a few days after it is made, by abſorbing partly air and partly moiſture.—3 Watſon, p. 43. And, according to Doctor Prieſtley, 15 per cent. in a month; and this ſeems its *maximum*.—3 Prieſt. p. 417. new edit. But coaks gain only 3 per cent.—3 Wats, p. 46. and ſtill leſs when well burned. Theſe deductions being made, it will be found that the abovementioned 600lbs. of charcoal will be reduced to 510, and the 403lbs. of coak to 391*; the difference then is only 119lbs.

To account for the equality of reſults, notwithſtanding this difference, we muſt conſider that coal containing aſphalt, a much denſer ſubſtance than any vegetable oil, is never ſo thoroughly chared as woods are, as Doctor Watſon has alſo hinted; ſo we have ſeen that Newcaſtle coal is reduced only 72 per cent. though

* Here I muſt mention an error of impreſſion in Mr. Lavoiſier's Memoires, which may deceive: In the text, p. 386, the quantity of coaks is ſaid to be 552, but in the third table, p. 391, it is ſaid to be 403; ſo alſo in the text the quantity of charcoal is ſaid to be 960, and in the table only 600, though the *meaſures* of both are the ſame in both pages. However I found the text wrong and the table right.

though it contains but 58 per cent. of carbon. Coaks therefore always retain ſome remains of bitumen, and conſequently of hydrogen; and in this caſe $\frac{1}{3}\frac{1}{3}\frac{2}{3}$ or 39 parts of hydrogen would compenſate for the defalcation of 119 of carbon.

On the other hand, if we compare the quantities of pit coal and charcoal we ſhall find that 100 parts of ſuch pit coal as is commonly chared, containing at a medium 60 per cent. or more of mere carbon, 600lbs. of it ſhould contain 360 of carbon, or perhaps more; and as it alſo contains much hydrogen, it might be expected to give out a much greater proportion of heat than 391 of coak or 510 of charcoal; but here we muſt take into the account the vaſt quantities of ſmoke and ſoot it throws out, which abſorb a large proportion of its heat, and moreover the bottom of the veſſels heated by it are moſtly covered with ſoot, which conſiderably obſtructs the communication of heat.

The ſame obſervations are in great meaſure applicable to woods. According to Doctor Watſon oak yields but 22 per cent. of charcoal by diſtillation, and ſtill leſs when chared; and beech, according to Wiegleb, only 20 per cent. conſequently 1089 parts of oak yield but 239 of carbon, the remainder of the heat then proceeds from the hydrogen contained in the oils of the wood.

Mr.

Mr. Lavoisier has alſo given the cubic meaſures of theſe combuſtibles, and the times in which each of them produced the ſame effect. For the ſatisfaction of the curious I ſhall expreſs the whole in the following table:

Combuſtibles.	Weight. lbs.	Meaſure. Cub. Feet.	Duration. Hours.
Pit coal -	600 -	10 -	20
Coaks - -	403 -	17 -	$12\frac{1}{2}$
Charcoal -	600 -	40 -	5
Oak - -	1089 -	33 -	4.4

Hence we ſee that if coal produces a certain quantity of heat in a given time, coaks in much ſmaller quantity will produce the ſame effect in little more than half that time, an equal weight of charcoal in one-fourth of that time, and oak in nearly double the weight of the coal in about one-fifth of that time.

The beſt coal for common uſes ſeems to be that which contains no pyritous, earthy or ſtony matter, and in which the carbonaceous is to the bituminous part in the proportion of 5 to 4, or 6 to 4,5. An equal mixture of maltha and aſphalt is preferable to either ſingly.

SYNOPTICAL VIEW *of the* STATE *of the* WEATHER *in* DUBLIN. *By* RICHARD KIRWAN, *Esq; L. L. D. F. R. S. and M. R. I. A.*

Read January 9, 1796.

1794.	BAROMETER. Higheſt.	Day it happened.	Loweſt.	Day it happened.	Mean of the Month.	THERMOMETER. Higheſt of the Day.	Loweſt at Night.	Mean.	RAIN. Days.	Inches.
January - -	30,67	21ſt W.	29,20	25. NW.	30,152	55,50	27,—	39,63	7. & 3. of Snow	—,591145
February -	30,34	8. & 26. NW.	29,35	23. Var. W. to S.	29,846	58,—	35,—	47,68	20.	2,325174
March -	30,63	21. E.	29,45	18. S. & SW.	30,02	62,—	32,50	50,42	18.	1,261112
April - -	30,54	17. W. by S.	29,12	7. Var. NW. to NE.	29,932	63,—	36,50	50,74	22.	2,522224
May - -	30,71	16. E.	29,43	9. SW. & S.	30,179	69,50	38,50	52,26	18.	1,379340
June - -	30,53	1. E.	29,88	20. E.	30,219	75,—	46,—	61,13	14.	—,748784
July - -	30,59	9. N. & E.	29,66	23. E.	30,171	79,50‡	50,50	63,57	18.	2,325174
Auguſt - -	30,485	13. N.	29,71	6. NW.	30,090	75,—	46,—	60,58	19.	2,180665
September -	30,52	30. W.	29,31	20. S.	30,041	65,—	37,50	55,33	16.	1,8911668
October -	30,58	21. E.	29,44	5th S.	29,96	63,—	37,—	50,12	25.	2,377715
November -	30,42	13. NE.	29,14	28th W.	29,793	55,50	32,—	45,20	22.	7,676719
December -	30,61	16. W. by N.	29,48	Var. 2d SW.	30,030	55,—	32,—	41,32	19. & 1. of Snow	3,546877
Mean of the Year	30,552		29,437		30,036			51,915	218. & 4 light Snow	28,8260958 Total of the Year

‡ On the 2d of July Sixe's thermometer roſe to 81°,50 at one o'clock, P. M. At two o'clock it was 79°,50.

The greateſt height of the barometer was on the 16th of May, viz. 30,71 inches, and on the 21ſt of January, viz. 30,67 inches. Its loweſt ſtate was on the 7th of April, viz. 29,12 inches, and on the 28th of November, viz. 29,14.

The hotteſt day was the 2d of July, the thermometer ſtanding for about an hour at 81°,5. and moſt of the day at 79°,5. The greateſt cold took place in January, the thermometer being ſeveral times at 27°.

The wetteſt month was November, during which there fell the enormous quantity of 7,676719 inches on a ſquare foot, about twelve gallons. The drieſt was January, there having fallen no more than 0,59114 inches, not quite a gallon.

November was alſo the moſt ſtormy month.

View of the Seaſons.

SPRING.	Rain.		SUMMER.	Rain.		AUTUMN.	Rain.	
	Inches.	Days.		Inches.	Days.		Inches.	Days.
April -	2,52222	22	June -	0,74878	14	September -	1,89116	16
May - -	1,37934	18	July - -	2,32517	18	October -	2,37771	25
	3,90156	40	Auguſt -	2,18066	19		4,26887	41
				5,25461	51			

Hence

HENCE we ſee by the firſt table of the laſt volume, page 228, that the *Spring* was *wet*, whether we conſider the quantity of rain or the number of wet days.

THE Summer muſt be denominated *variable*, *inclining ſtrongly to wet*, whether we conſider the quantity or duration of the rain. The Autumn was alſo *very wet*.

Compariſon of the Seaſons with the Rules of Prognoſtication.

THE Spring being wet the probability of a wet Summer was the greateſt by the third table, being $\frac{5}{6}$; but that of *variable wet* was nearly as great, being $\frac{4}{6}$ by the ſixth table.

THE Spring being *wet* and the Summer *variable wet*, the probability of a dry Autumn ſtands greateſt in my tenth table. If this rule be true, this year is an exception to that rule. The fifth table left it doubtful whether the Autumn would be dry or variable. The fourth table indicated a variable.

Of the Winter preceding the Spring of 1794.

	Rain.		Mean.		Storms.
1793.	Inches.	Days.	Barometer.	Heat.	
October -	2,7192	17	29,90	44,35	8. SE. SW.
December - -	1,8128	17	29,81	43,51	2. SW.
	4,5320	34	29,85 Mean	43,93	
1794.					
January - -	0,59114	10	30,15	39,63	O.
February - -	2,32517	20	29,84	47,68	4. ESE. NE.
March - -	1,26111	18	30,02	50,42	2. NE. W. SW.
	4,17742	48	30,00 Mean	45,91	
Total -	8,70942	82	29,92 Mean	45,91	

Synoptical

1795.	BAROMETER. Higheſt.	Day it happened.	Loweſt.	Day it happened.	Mean of the Month.	THERMOMETER. Higheſt in the Day.	Loweſt at Night.	Mean.	RAIN. Days.	Inches.	STORMS. No.	Winds.
January -	30,63	10th SE. & S.	29,20	27th W. & N.	30,195	44,—	19,50	32,98	4. & 11. of Snow	2,403994		
February - -	30,84	16th E. calm	28,95	10th & 11th var. E. to SW.	29,762	53,—	23,50	36,53	8. & 11. of Snow	2,285765	4.	E. by S. S. SE. NE.
March -	30,50	20th W. & SW. high	29,32	10th W. high	29,919	55,—	24,50	41,985	15. & 2. of Snow	2,206946	2.	NW. SW.
April - -	30,48	5th N. & N. by E.	29,33	19th W.	29,873	67,—	34,50	47,066	16. & 4. of Hail	2,364585	4.	SW. W. & SE.
May - -	30,73	27th E. by N.	29,80	1ſt NW.	30,393	75,50	35,—	54,025	12.	0,604275		
June - -	30,47	19th NE.	29,57	28th N. by W.	30,104	73,—	41,50	55,775	14.	2,679863		
July - -	30,68	7th & 8th E.	29,83	22d NW. high	30,304	75,—	46,—	60,525	12.	1,090322		
Auguſt -	30,45	28th & 29th SW.	29,64	2d SW.	30,101	78,—	49,50	62,69	14.	0,630556		
September -	30,64	14th SW.	29,57	5th SE.	30,230	72,—	45,—	59,68	11.	0,354687		
October -	30,27	1ſt E.	28,94	10th S.	29,644	63,—	41,—	52,872	24.	6,6208	2.	S. by E. NW.
November -	30,88	11th NE. calm	28,98	18th W. by N.	30,025	55,50	28,50	41,416	16. & 1. of Snow	2,850632	3	W. by N. SW. & S.
December -	30,60	9th E.	29,08	13th SE.	30,013	57,—	32,50	44,75	21.	2,390845	9.	SW. W. NW.
Mean of the Year	30,597		29,35		30,047			49,191	196, on 25 of which there fell Snow	26,483270 Total of the Year	24.	Total in the Year.

THIS

This year was remarkably colder than the laſt.

The greateſt height of the barometer happened in November, viz. 30,88. The loweſt in October, viz. 28,94.

The hotteſt days was on the 12th and 20th of Auguſt, the thermometer being at 78° on theſe days.

The greateſt cold happened on the night of the 22d of January, the thermometer being at 19°,5, but in the country it was, as uſual, one or two degrees lower.

The wetteſt month was October, the fall of rain being 6,6208 cubic inches, and its continuance 24 days. The drieſt was September, there having fallen only 0,354687 of an inch, and only during eleven days.

View of the Seaſons.

SPRING.	Rain.		SUMMER.	Rain.		AUTUMN.	Rain.	
	Inches.	Days.		Inches.	Days.		Inches.	Days.
April -	2,36458	16	June -	2,67986	14	September -	0,35468	11
May -	0,64275	12	July - -	1,09032	12	October -	6,6208	24
	3,00733	28	Auguſt -	0,63055	14		6,97548	35
				4,40113	40			

By

By the firſt table the Spring muſt be deemed nearly *dry* or *variable dry*.

By the ſecond table the Summer was alſo *variable dry*, but nearer to variable than to dry. By the third table the Autumn ſhould be deemed *wet*, but in fact it was *Bipartite*, one month, viz. September, being exceeding dry, and the other, October, exceeding wet.

Compariſon of the Seaſons with the Rules of Probability.

The *Spring* being *dry* the probability of a dry Summer was greateſt, being $\frac{22}{41}$ in the ſecond table.

The *Summer* being *variable dry* the probability of a variable Autumn was greateſt by the ninth table.

The Spring being *dry* and the Summer *variable dry*, the probability of a wet and variable Autumn were equal by the tenth table. This year then the prognoſtics anſwered remarkably well.

Of

Of the Winter preceding the Spring of 1795.

	Rain.	Days.		Mean. Bar.
1794.				
November - -	7,67671	22		29,79
December - -	3,54687	20		30,03
	11,22358	42	Mean -	29,91
1795.				
January - -	2,40399	15		30,19
February - -	2,28576	19		29,76
March - - -	2,20694	17		29,91
	6,89669	51	Mean -	29,95
Total -	18,12027	93	Mean of both -	29,93

THE quantity of rain that fell this Winter was nearly double that which fell in the Winters of 1793 or 1794. The Summers and Autumn of thoſe years were wet, but in this dry, or nearly ſo. If this holds frequently it will form a valuable prognoſtic.

THOUGHTS *on* MAGNETISM. *By* RICHARD KIRWAN, *Eſq*; *L.L.D. F.R.S. and M.R.I.A.*

1. THERE are two ways of explaining a natural phænomenon; the firſt, is by diſcovering the conditions and circumſtances of its production and the laws by which its action is governed; the ſecond, is by ſhewing its analogy, ſimilarity or coincidence with ſome general fact with whoſe laws and exiſtence we are already acquainted; this laſt mode is by far the moſt perfect and ſatisfactory. In the firſt ſenſe of the word electricity and magnetiſm have been in ſome meaſure explained, but in the laſt ſenſe neither; the primary cauſe of magnetiſm in particular has hitherto been ſuppoſed to relate to iron alone, or its ores, and to ſtand unconnected with all other natural phænomena.

Read March 19, 1796.

2. IF therefore any other general fact or power can be diſcovered to which it bears ſome analogy or ſimilarity, it may ſo far be ſaid to be explained. Now ſuch fact or power I think may be aſſigned, namely, the power of *cryſtalization*.

3. By cryſtalization I underſtand that power by which the integrant particles of any ſolid poſſeſſing ſufficient liberty of motion unite to each other, not indiſcriminately and confuſedly, but according to a peculiar uniform arrangement, ſo as to exhibit in its laſt and moſt perfect ſtage regular and determinate forms.

4. This power is now known to be poſſeſſed by all ſolid mineral ſubſtances.

5. The forms which cryſtals, even of homogeneous ſubſtances, exhibit, are often very numerous; however in moſt caſes they may be reduced to a few primordial forms, which, as Abbé Hauy has lately experimentally proved, are derived from certain original forms appertaining to the minuteſt particles of their concretion.

6. The aſſemblage of theſe ultimate particles into viſible aggregates, ſimilarly arranged, neceſſarily requires that one of their ſurfaces ſhould be attractive of that particular ſurface of the other, which preſents a correſponding angle, and repulſive of that which preſents a different angle, otherwiſe the various regular rhomboidal and other polygon priſms and pyramids, which cryſtals preſent us, could never exiſt; conſequently the minuteſt priſm, being once formed, could never be prolonged if one end of ſuch priſms were not attractive, and the other repulſive of the ſame given ſurface.

7. Hence it has been obſerved that cryſtalization never takes place in the middle of any ſolution, but always begins at the ſurface

face or on the bottom or ſides of the veſſels that contain it, for the particles in the middle of the ſolution being confuſedly mixed with each other, and exerting their repulſive as freely as their attractive powers, the one conſtantly counteracting the other, no ſenſible accretion of a regular kind could take place, whereas the repulſive power of the uppermoſt particles, or of thoſe that reſt on the ſides or bottom of the veſſel, is reſtrained and impeded.

8. The repulſive power of cryſtalizing ſubſtances alſo appears in many other inſtances (of the attractive no doubt has ever been formed.) Thus if ſaturate ſolutions of nitre, common ſalt, and tartar vitriolate be mixed and ſet to cryſtalize, each will cryſtalize a part, which could not happen if the particles of each of theſe ſalts did not only attract their ſimilar homogeneous, but alſo repel thoſe of a different ſpecies, otherwiſe the mere caſual circumſtance of greater proximity to one than to the other would impel them to unite indiſcriminately. Again, if a ſaturate ſolution of allum be mixed with a turbid mixture of clay, and abandoned to inſenſible evaporation, after ſome time the clay will ſubſide and form a dry maſs, but in the interior of this maſs large regular cryſtals of allum will be found, whoſe component particles muſt, to reunite, have diſplaced and repelled the particles of clay with which they were ſurrounded.

9. If to a ſaturate ſolution of a ſalt that difficultly cryſtalizes, a cryſtal of a ſalt of the ſame ſpecies be inſerted, the whole ſolution will ſoon be brought to cryſtalize, as the cryſtal inſerted

attracts the particles diſſolved, by its different ſurfaces; but if a ſalt of a different nature be inſerted this will not happen, cryſtalization will not be promoted.

10. If to a ſolution of 2 parts nitre, and 3 parts Glauber's ſalt in 5 parts water, a cryſtal of nitre be inſerted, the nitre alone will cryſtalize; or if inſtead of nitre a cryſtal of Glauber be inſerted into it, the Glauber alone will cryſtalize. Do not theſe experiments fully evince both the attractive and repulſive powers, not only of different ſalts but of different ſurfaces of the ſame ſalt?

11. These powers within their proper ſphere of action have been found indefinitely great; thus water confined in cannon ſeveral inches thick, and expoſed to a degree of cold much beneath the freezing point, has been obſerved to cryſtalize into ice that burſt the metallic impediment oppoſed to the form it then aſſumes.

12. The vaſt difference however attending the developement of theſe two powers (of magnetiſm and cryſtalization) will undoubtedly ſtrike many as an inſuperable objection to their identity, yet their *direction* in all its varieties being exactly the ſame, difference in other circumſtances ſeems to me to indicate rather a variety of *degrees*, in the ſame power, than any eſſential difference in the powers themſelves.

I now

I now come to the application of the above principles to the magnetic phænomena. Theſe may in general be reduced to the following, viz. *Attraction*, *Repulſion*, *Polarity*.

Communication.

Declination.

Inclination.

Excluſive appropriation to Iron.

Deſtruction of the Magnetic power.

1ſt, Attraction, Repulſion, Polarity.

The quantity of iron found on and within ſuch parts of the ſurface of the globe as we are acquainted with, far ſurpaſſes that of any other mineral ſubſtance ſingly taken, or even of many of them taken together; ſcarce any ſtone or metallic ore or earth is found free from it; it enters into their compoſition in the proportion of from 2 to 18 or 20 per cent. and perhaps at a medium we may ſtate it in all of them at 6 per cent.; moreover its own ores are of all others the moſt common and the moſt copious; in many places, particularly in the moſt northern climates, whole mountains of it are found, and many of them magnetic. When to this conſideration we add that of the ſpecific gravity of the globe, which has been found to be 4,5 times heavier than water, notwithſtanding the immenſe quantity of water that covers the greater part of its ſurface to conſiderable unknown depths, and notwithſtanding

notwithſtanding that the ſpecific gravity of by far the greater part of the ſtones and earths it contains does not exceed and ſcarcely amounts even to three times the weight of an equal bulk of water, and that the quantity of mineral ſubſtances whoſe ſpecific weight exceeds four times that of water is almoſt infinitely ſmall in compariſon to the other known component parts of the globe, and finally that the weight of moſt iron ores is about four or five times that of water; all this I ſay conſidered, it is difficult to avoid concluding that the interior part of the globe conſiſts chiefly of iron ore diſpoſed in one or more aggregate maſſes; a concluſion that is farther confirmed, on reflecting that volcanic lavas ejected from the deepeſt receſſes with which we are acquainted contain from 15 to 20 or 25 per cent. of iron in the ſtate moſt favourable to magnetic attraction.

TAKING then this aſſertion to be as fully proved as its ſubject matter is capable of being aſcertained, we may deduce from it the following corollaries:

1ſt. THAT as the ferruginous matter in the globe being by far the moſt copious, its univerſal attractive power is principally ſeated in the ferruginous part.

2d. THAT as all terraqueous matter was originally in a ſoft ſtate, its parts were at liberty to arrange themſelves according to the laws of their mutual attraction, and in fact did coaleſce and cryſtalize

cryſtalize in the direction in which they were leaſt impeded by the rotatory motion of the globe, namely in that which extends from North to South, and principally and moſt perfectly in the parts leaſt agitated by that motion, namely thoſe next the centre.

3d. That this cryſtalization like that of ſalts might have taken place in one or more ſeparate *ſhoots*, or as we may here call them, immenſe ſeparate maſſes, each having its poles diſtinct from thoſe of the other, thoſe in the ſame direction repulſive of and diſtant from each other.

In conſequence then of the univerſal law of attraction of the particles of matter to each other, theſe internal magnets exert a *double* power of attraction; the firſt and moſt general, on the particles of *all* bodies indiſcriminately in proportion to their denſity, and the direct or inverſe ratio of the ſquares of their diſtances according as thoſe bodies are found within or without the earth's ſurface; and the ſecond, on bodies of their own ſpecies in proportion to their homogenity, and to the correſpondence of the arrangement of their integrant particles with that of the integrant particles of theſe internal magnets.

A magnet therefore is a maſs of iron, or of iron ore, whoſe oxygenation does not exceed 20 per cent. or thereabouts, whoſe particles are arranged in a direction ſimilar to that of the great internal central magnets of the globe. This I call the *magnetic arrangement*.

The

The particles of iron attract each other more forcibly than thoſe of any other known ſubſtance. This appears by its coheſion, hardneſs, elaſticity and infuſibility, in each of which properties, or at leaſt in the combination of moſt of them, it exceeds all other known bodies.

Hence a magnet *attracts iron* when within the ſphere of its action, by forcing, in virtue of its attractive power, a certain proportion of its integrant particles into a diſpoſition and arrangement ſimilar to that of its own. For in this caſe it exerts a double attractive power, that of the particles of iron to each other, which we have ſeen to be the greateſt of all others, and that of cryſtalizing bodies, which we have alſo ſeen to be indefinitely great.

The cryſtalizing power being at once attractive and *repulſive*, according to the direction of the ſurfaces, (No. 6.) hence we ſee that one part or end of the magnet muſt repel that which the other has attracted, as long as the ſame diſpoſition of parts remains.

The diſpoſition of parts in a particular magnet, being ſimilar to that which obtains in the great internal general magnet, extends in the direction of from North to South. Hence magnets, when at liberty to move with a certain degree of freedom, and iron, when a ſufficient number of its particles are arranged in that

that direction, and has ſufficient liberty to conform to it, points to thoſe poles. Hence this property is called *Polarity*.

The magnetic power is greater or leſſer according to the number and homogenity of the particles *ſimilarly* and *magnetically* arranged. Hence ſmall magnets may be more powerful than a larger, and hence a magnet will attract a magnetized needle at a greater diſtance than one not magnetized.

The magnetic power decreaſes in a certain ratio of the diſtance of the particles that exerciſe it. Hence it is ſtrongeſt in the point of contact, and at the poles, as it is there moſt *unſaturated*, and weakeſt in the central part, which ſeparates the two oppoſite poles.

When a magnet is broken into ſmall pieces its power is nearly deſtroyed, becauſe though the poles ſhould be all of the ſame kind, yet the diſtance of each from the oppoſite pole is ſo ſmall that their powers counteract and conſequently deſtroy each other.

If when a needle is attracted by the ſouth pole of a magnet a bar of iron be placed on the north pole, the needle is ſtill more ſtrongly attracted, becauſe the iron acquires alſo a ſouth pole, whoſe force is joined to that of the magnet.

If two needles be ſuſpended from any given pole of a magnet they will diverge, becauſe they both acquire the ſame polar arrangement. If a bar of iron be laid on that pole of the magnet the divergence will diminiſh, becauſe the next end of the iron will acquire the diſpoſition of the oppoſite pole, and conſequently counteract the repulſive power of the magnet.

A magnet will not tranſmit its power through a bar of iron if this be too long. Muſchenbruck limits their length to ſix feet, but this depends on the ſtrength of the magnet.

The power of a magnet (every thing elſe being equal) depends on the *number of its ſurfaces magnetically arranged*, and the *accuracy* of that arrangement.

The arrangement is accurate when the ſynonimous ſurfaces are exactly parallel to each other, and originally conformed to and parallel with thoſe of the great general magnet.

The magnetic attraction is ſtrongeſt in the direction perpendicular to the magnetic ſurfaces, and weakens in proportion to the magnitude of the angle of direction with the perpendicular, and conſequently is *null* when at a right angle with it. Hence the magnetic power ſeems concentrated at the *poles*, and the lateral powers are the weakeſt, as they originate only in the oblique direction of ſurfaces, or from ſurfaces inaccurately arranged.

If

If the ſouth pole of a magnet be charged with filings of iron, and then approached to a bar of iron ſtanding erect, part of the filings will drop off, becauſe the poles of the ſame name, by exciting a contrary arrangement, weaken each other; but if the filings were ſuſpended from the north pole of the magnet it would take up ſtill more of the filings, as the oppoſite poles ſtrengthen each other, the uppermoſt pole of the iron in this caſe becoming magnetic by poſition.

If the ſynonimous poles of two magnets of unequal powers be approached to each other, if the powers be very unequal the ſtronger immediately deſtroys the weaker, and inducing a contrary diſpoſition attracts inſtead of repelling it; if the powers be leſs unequal it requires a longer time; ſo alſo if one be *ſofter* than the other. Even if their powers be equal, yet after ſome time the ſofter will yield to the harder. If both be equally hard they only *weaken* each other.

If a magnet be cut in two, in a direction parallel to the axis, the parts before conjoined will now repel each other, becauſe they ſtill retain two ſynonimous poles.

But if the magnet be cut in two in a direction perpendicular to the axis, the two ends before conjoined will now attract each other.

If a magnetic wire be twiſted, its powers are ſo diſordered that one ſide of the wire, in ſome places of it, will be attracted and the other ſide repelled by the ſame pole of the magnet.

The power of magnets (cæteris parib.) is in proportion to their ſurfaces or as the ſquares of their diameters.—See Hutton's Magnetiſm, p. 72.

Communication.

When iron is applied to or brought within the ſphere of activity of a particular magnet, it acquires the arrangement requiſite to form the heteronymous pole, and thus becomes itſelf in ſome degree magnetic in its whole length, if this length be not totally diſproportioned to the power of the particular magnet.

Hence the other end of ſuch bar of iron acquires the arrangement of the oppoſite pole, according to the laws of cryſtalization already laid down.

Iron becomes magnetic either by contact or proximity to a magnet, or by poſition, or by internal commotion.

If a bar of iron be placed in a vertical poſition its inſenſible fibrillæ gradually acquire the magnetic arrangement, ſo that after ſome years it becomes a complete magnet, its *loweſt* part becoming a north pole, that is, pointing when free to the north, and

and the *upper* a ſouth pole. In the S. hemiſphere the under end becomes a ſouth pole.

A BAR of iron not previouſly magnetic does not acquire this diſpoſition in the ſlighteſt degree while lying in a horizontal or nearly a horizontal diſpoſition, but if one end of it be raiſed it immediately acquires it in ſome degree, as appears by approaching a magnetic needle to either end, becauſe in that direction it is then expoſed to the activity of the polar ends of the great general magnet.

BUT if a bar of iron be heated, though only at one end, and while hot ſet in a vertical or nearly a vertical poſition, it will acquire the magnetic power much more readily.

So alſo if one end of a bar of iron not magnetic be ſtruck againſt the ground it will become in ſome degree magnetic, the lower end becoming a north pole, &c. and if afterwards the other end be ſtruck in the ſame manner the poles will be reverſed.

HENCE it is evident that *any motion* communicated to the integrant particles of iron placed in a proper ſituation helps them to aſſume the magnetic diſpoſition already impreſſed upon them by the great general magnet.

IF the oppoſite poles of two magnets of *equal power* be approached to each other the power of both is increaſed; and if

if one of them be *more powerful* than the other it will increaſe the magnetic diſpoſition, and conſequently the power of the weaker.

Soft iron, as its parts are moſt eaſily moved, receives the magnetic diſpoſition moſt eaſily, *hard* iron or tempered ſteel more difficultly, and *caſt* iron, as being both hard and abounding in the heterogeneous particles, moſt difficultly and imperfectly.

WHATEVER way iron is applied to a magnet the magnetic power is diffuſed in the direction of its length. Hence it ſhould ſeem that when a bar of iron is laid on a magnet the contiguous ends of the iron become poles of the *ſame name* with thoſe of the magnet to which they are contiguous, and hence may be derived the power of *armed magnets*, for the ſurfaces of the *armour* immediately beneath thoſe of the magnet impreſs a direction oppoſite to their own on thoſe of the magnet, and conſequently rectify ſuch ſurfaces of the magnet as may have been inaccurately directed, and thus ſtrengthen it.

To communicate the magnetic power to iron by friction againſt a magnet, it is neceſſary that its pole ſhould ſlide along the magnet ſeveral times in the ſame direction, for if the directions be alternately oppoſed the powers received will ſucceſſively deſtroy each other.

A SYNONIMOUS pole is formed at the end at which the friction begins, to that of the magnet applied, and an oppoſite at that at which it terminates.

Appropriation

Appropriation to Iron.

It has of old been obſerved that the magnetic phænomena were peculiar to iron, and the reaſons why they are ſo have been already aſſigned, but of late ſome ſemi-metals have been obſerved to partake of theſe properties, as Nickel, Kobalt and Manganeſe; this has been thought to ariſe from a mixture of ferruginous particles from which they can be ſcarcely freed, and with reſpect to Manganeſe, and in many caſes of the others alſo, this ſeems to hold true; but with reſpect to Nickel, and in ſome inſtances of the others alſo, the magnetic properties they diſcover ſeem to me to proceed from their great attraction to iron, particularly when their particles are duly arranged, for then they are expoſed to the power of the great general magnet, which acts on them in proportion to this arrangement and their affinity to iron.

Of Inclination and Declination.

These phænomena, which are ſo different in different parts of the globe, and even in different ſeaſons and hours of the day, not being as yet noted with ſufficient certainty and preciſion, I ſhall for the preſent decline entering into their explanation.

On the METHOD *of* DETERMINING *the* LONGITUDE, *by* OBSERVATIONS *of the* MERIDIAN PASSAGES of the MOON *and a* STAR *made at two Places. By the Rev.* JAMES ARCHIBALD HAMILTON, *D. D. Profeſſor of Aſtronomy at Armagh.*

Read Nov. 1, 1794.

General Rule for determining the eſtimate difference of the Longitude of a given place, from ſome well known meridian, by obſervations of the different intervals of A. R. of the moon's enlightened limb from a ſtar at each place on the ſame day.

LET the paſſage of the moon's enlightened limb be carefully obſerved to the neareſt tenth of a ſecond, over the ſeveral wires of the tranſit inſtrument, and let its paſſage over the centre be deduced by taking a mean of its paſſages over the equidiſtant wires, properly reduced. Let one or more fixed ſtars that lie near her parallel of declination, and alſo as near to her in A. R. as can conveniently be had, be obſerved in like manner. Let the rate of the ſydereal clock, which is the moſt convenient for this purpoſe, be carefully aſcertained, and from this and the obſervations collect the exact difference of the moon's A. R. from

one or more of theſe ſtars under your own meridian. Having obtained correſponding obſervations from ſome ſettled obſervatory, find the difference of the differences of A. R. of the moon's limb from the ſame ſtar, under each meridian; take from the ephemeris her increaſe of A. R. for the 12H. including the obſervations, and ſay: As this quantity of A. R : 12H : : the apparent difference of the obſerved differences of A. R. to the eſtimate difference of longitude. This eſtimate difference will always be exact enough to enable you from tables or by calculation to find the corrections to which the obſervations and the lunar rate muſt neceſſarily be ſubjected, to deduce from them the true difference of longitude between the reſpective places of obſervation. To elucidate the nature and grounds of theſe ſeveral corrections, I ſhall premiſe ſome general conſiderations on the obſervation of the difference of A. R. of the moon's enlightened limb from a ſtar, and of the equation of the moon's increaſe of A. R. in 12H. as given in the ephemeris.

As this is acknowledged to be one of the moſt certain and convenient obſervations for determining the longitudes of places, the reduction that is required to give it its due accuracy ſeems deſerving of a more diffuſive explanation than as far as I can find has been hitherto beſtowed on it by any of the writers on practical aſtronomy. Mr. Vince, in his late treatiſe, mentions this method, as having been recommended by Dr. Maſkelyne in the year 1769; and reports the ſucceſsful

ful application of it by Mr. E. Pigott, then of York, in deducing the difference of longitude of his obſervatory from that of Greenwich. Both he and Mr. E. Pigott, to whom indeed we principally owe the advantages that may, and moſt probably will accrue to geography from this method, beſides ſtating the general proportion, mention, that when the moon's rate is irregular attention ſhould be paid to that circumſtance; and Mr. Vince further adds, that the accuracy of the reſult will be greater, if we allow for the difference of the increaſe of the moon's A. R. in the intervals of the paſſages of the two meridians over the moon and ſtar, for that the obſerved difference is not accurately the true difference, when the two meridians paſs the ſtar.

As the fixed ſtar is the permanent and immutable term of the compariſon for both meridians, Mr. Vince very juſtly refers the difference of A. R. that is to be determined to the actual moment under each meridian, that theſe meridians apply to the ſtar and not to the moon's enlightened limb. The queſtion then, in its moſt ſimple and accurate form is, when the meridians ſucceſſively apply to the ſame ſtar, what is *then* the preciſe difference of the A. R. of the moon's enlightened limb from that of the ſtar for each meridian?

To elucidate this point—Let us ſuppoſe the paſſages to be obſerved by a clock, moving ſydereal time, and the meridian applies firſt to the moon's enlightened limb; its A. R. is then

 denoted

denoted by the clock. The ſame meridian preſently arrives at the ſtar, whoſe A. R. is in like manner expreſſed by the clock. The time elapſed between the obſervations would be the true interval of their A. R's. ſuppoſing the moon to have ſtood ſtill in her orbit—But the moon was increaſing her A. R. during the whole of the elapſed time; and of courſe every moment approaching nearer to the ſtar, therefore when the ſtar paſſed their difference of A. R. was decreaſed by the quantity of A. R. gained by the moon during the interval of ſydereal time elapſed ſince her own paſſage. If then a given meridian ſhould paſs the moon at 12H. and a ſtar at 14Hs. their apparent difference of A. R. would be 2H. and their true difference of A. R. at the moment of the paſſage of the ſtar would be the apparent difference—the moon's increaſe of A. R. in 2H. If under another meridian the moon ſhould paſs at 12H. 1′, and the ſtar at 14H. then their apparent difference of A. R. under that meridian would be 1H. 59′, — and their true difference A. R. at the time of the ſtar's paſſage 1H. 59′—the moon's increaſe of A. R. in 1H. 59′. Therefore the actual difference of theſe obſerved differences of A. R. is not the true quantity required, but muſt be leſſened by a quantity of A. R. proportioned to the moon's rate in her orbit; and the difference of the two ſydereal intervals of 2H. and 1H. 59′.; for let us ſuppoſe the moon to increaſe her A. R. at the regular rate of 30′ of a degree for an hour, and a meridian to paſs her firſt limb at 12H. and that the ſame meridian applies to a ſtar

at

at 14H. at the time therefore of the ſtar's paſſage, the moon had ſince her own paſſage approached the ſtar by 60′ of motion = 4′ in time : 2 H.—4′ or 1H. 56′ was the true interval of A. R. between theſe heavenly bodies when the ſtar paſſed. Let us again ſuppoſe the moon to move at the ſame rate in her orbit, and another meridian to paſs over her firſt limb when it had 12H. 1′ 0″ of A. R. The ſtar ſhe was before compared with being a fixed point, will be found by this ſecond meridian at its permament ſtation of 14H. and to get the true difference of the moon's A. R. from the ſaid ſtar at the inſtant of its paſſage 1H. 59′ the obſerved difference muſt be leſſened by the moon's increaſe of A. R. in 1H. 59′=to 59′. 30″ of motion, or 3′ and 58″ of time.

EXAMPLE.

Firſt Meridian.	H.	′	″
☽ 1 limb paſſes at - - -	12	0	8
Star paſſes at - - - -	14	0	0
Apparent difference of their A. R's. -	2	0	0
Deduct the moon's increaſe of A. R. in 2Hs.	0	4	0
True difference of their A. R's. when the ſtar paſſed	1	56	0

Second

Second Meridian.	H.	′	″
☽ 1 limb paſſed at - -	12	1	0
Star paſſed at - -	14	0	0
Apparent difference of A. R's. -	1	59	0
Deduct for moon's increaſe of A. R. in 1H. 59′ 0″ - -		3	58
True difference of their A. R's. when the ſtar paſſed	1	55	2
Apparent or obſerved difference of A. R. at 1ſt meridian	2	0	0
Apparent or obſerved difference of A. R. at 2d ditto	1	59	0
Apparent difference of ☽'s A. R. for the interval of the meridians - - - -	0	1	0
True difference of A. R's when the ſtar paſſed 1ſt meridian	1	56	0
True difference of A. R's when the ſtar paſſed 2d meridian	1	55	2
True difference of ☽'s A. R. for the interval of the meridians - - - - -	0	0	58

Let us now take an example, at the ſame lunar rates and intervals of meridians as before, only ſuppoſing the ſtar to precede the moon.

Firſt

First Meridian.	H.	′	″
Star paſſes at - - -	12	0	0
☽'s 1 limb paſſes at -	14	0	0
Apparent or obſerved difference of their A. R's	2	0	0
Deduct for moon's increaſe of A. R. ſince the ſtar paſſed	0	4	0
True differenee of their A. R's when the ſtar paſſed -	1	56	0

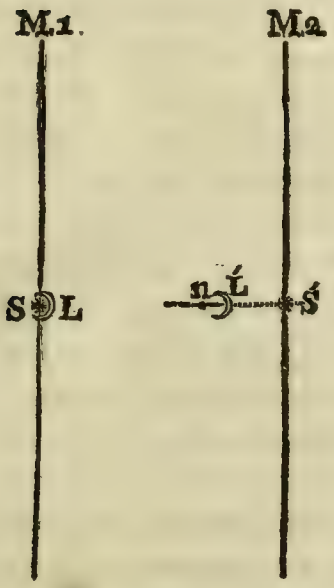
Second Meridian.			
Star paſſes at - - -	12	0	0
☽ 1 limb paſſes at - - -	14	1	0
Apparent or obſerved difference of their A. R's.	2	1	0
Deduct for ☽'s increaſe A. R. in 2H. 1′ ſince the ſtar paſſed	0	4	2
True difference of their A. R's when the ſtar paſſed -	1	56	58

Apparent or obſerved difference of A. R's at 1ſt meridian	2	0	0
Apparent or obſerved difference of A. R's at 2d meridian	2	1	0
Apparent change of ☽'s A. R. for the interval of meridians	0	1	0
True difference of A. R. when the ſtar paſſed 1ſt meridian - - - - -	1	56	0
True difference of A. R. when the ſtar paſſed 2d do.	1	56	58
True change of ☽'s A. R. for the interval of meridians	0	0	58

Hence

HENCE it is evident, that in each caſe the obſerved difference of the differences of A. R. is to be leſſened by a quantity proportioned to the moon's ſuppoſed uniform rate, and the interval of the meridians; the moon's rate therefore being given, the abſolute quantity of the correction will depend on the diſtance of the meridians aſunder.

NOTE—The whole of the ſydereal interval between the paſſages of the moon's enlightened limb and the ſtar, being common to both places of obſervation, 1′ only excepted, it is for this minute only which is the difference of the ſydereal interval between the moon and ſtar at the ſeparate places of obſervation, ariſing from the moon's motion in her orbit during the interval of the paſſages of the two meridians, that the effective correction, amounting to 2″ in this inſtance, takes place.



The ſimpleſt form that can be deviſed for explaining the nature of this correction, is to ſuppoſe, as in the annexed figure, that the moon's enlightened limb L′, and a ſtar S on her parallel, apply at the ſame inſtant to 1ſt meridian M. 1. then the true and obſerved difference of A. R. will there be the ſame, viz. 0. then let the ſtar S′ apply to a ſecond meridian M. 2. 3 H. diſtant from the former; and let the moon changing her A. R. at the uniform rate of 24′ time in 12 hours be arrived at the point L′, having receded from the ſtar

by 6′ of A. R. in time, when the ſtar S′ is on the 2d meridian, and the interval L′ S′ the difference of A. R. which compared with the moon's increaſe of A. R. in 12H. will give the difference of meridian or of longitude. But while the point L is coming to the 2d meridian the moon will have receded to the point $^{n}_{.}$, and when her enlightened limb arrives at the 2d meridian the obſerved difference of A. R. between the ſtar and it will be ^{n} S′ and the correction of this obſerved difference will be $^{n}_{.}$ L′, it is obvious this quantity will increaſe with the quantity L′ S′, and the quantity L′ S′ will be in the direct proportion of the increaſing interval of 1ſt and 2d meridian, and of the moon's actual rate in her orbit.

If the moon is not compared with any particular ſtar at either meridian, but her apparent A. R. on the meridian obſerved at each place by well regulated ſydereal clocks — The ſame correction of the obſerved difference of A. R. is required, as though her enlightened limb was compared with a given fixed ſtar; for in this caſe ſhe is, in fact, compared with an imaginary ſtar in the firſt of aries, her obſerved diſtances from which are ſubject to the ſame regulations as though there was a real ſtar at that point in the heavens.

It may be farther neceſſary to add on this ſubject, that if at the different places of obſervation the moon ſhould be on the oppoſite ſides of the ſtar with which ſhe is compared, then the

the ſum of the intervals of her A. R. from that of the ſtar is to be uſed in this calculation inſtead of the difference of theſe intervals.

When the meridians are even a moderate diſtance from each other, the neglect of the equation for the difference of the obſerved and true interval will have a very conſiderable influence on the reſult of the obſervations; when the moon moves at her quickeſt rate, and the meridians are only 10° aſunder, the correction amounts to 5″ of time on the obſerved interval, it will of courſe in all caſes require to be very ſtrictly attended to. To facilitate therefore this part of the operation, I have calculated a ſhort table, intitled "A table of corrections, &c." for which the correction of the interval for any lunar rate, and for any longitude not exceeding 10° may be taken out with ſufficient accuracy almoſt at ſight. The correction in this table is given in time to ſeconds, tenths, &c. that it may be directly applied to the difference of the A. R's. as found immediately by the tranſit inſtrument. The difference thus corrected is to be changed into parts of a degree, to prepare it for the analogy from whence the longitude is to be finally deduced.

We have hitherto conſidered the moon's rate in her orbit to be equable, but as this is ſeldom in reality the caſe, this method requires that when her rate is unequal, the ſum of her A. R. gained in 12H. ſhould be equated as nearly as poſſible,

according to the rate ſhe moved at, at the time of the mid-interval of the obſervations.

To explain this, let us ſuppoſe the moon, by an equable motion, to have changed her A. R. in 12H. by 6°, and on that day under a different meridian her difference of A. R. from the ſame ſtar with which ſhe had been compared at a former meridian was found to be encreaſed by 1°, then 6°: 12H. : : 1° : 2H. the longitude required. Now on another day let us ſuppoſe the moon to have gained as before 6° A. R. in 12H. but at the following rates for each hour of the 12H.

H.		H.		H.		H.	
1ſt	30′ . 6″	4	30′ . 3″	7	30′ . 0″	10	29′ . 56″
2	30 . 5	5	30 . 2	8	29 . 58	11	29 . 55
3	30 . 4	6	30 . 0	9	29 . 57	12	29 . 54

Should the moon's A. R. be compared with the ſame ſtar at the ſame places on this day at the beginning of the 12 hours ſhe will be found to have actually gained in the interval of the paſſages of the 2 meridians 1°. 0′. 11″. and the proportion unequated would be 6° : 12H. : : 1°. 0′. 11″ : 2H. 0′. 22″. and ſhould the obſervations happen near the end of the 12H. the moon would be found to have gained in the ſame interval only 59′. 49″. of A. R. and the unequated proportion would run thus, 6° : 12H. : : 59′. 49″ : 1H. 59. 38; whence it is evident that the longitude deduced from theſe obſervations would be in one caſe 22″ too great, and in the other 22″ leſs than the truth: This

ſource

ſource of error therefore ſhould be corrected before the proportion is ſtated, by altering the firſt term in conformity to the moon's actual rate during the interval between the obſervations. Thus in the firſt analogy the deviation in 2 hours from the mean rate of 30″ per hour is + 11″; this multiplied by 6 gives 1′ 6″, which added according to its ſign to the firſt term of the proportion would make it 6°. 1′. 6″, and the proportion would ſtand thus, 6°. 1. 6 : 12H : : 1. 0. 11″ : 2H. the ground and neceſſity of this correction are evident, and when it is not applied the irregularity of the moon's rate being given, the quantity of error will be greater or leſs in proportion as the obſervations were made at a part of the 12H. more or leſs diſtant from the hour of the mean rate. Had theſe ſuppoſed obſervations been made between the 5th or 7th hours the longitude would have come out true without any correction of the rate whatſoever.

Having premiſed thus much on the nature and grounds of this correction, I ſhall proceed to a ſhort explanation of the readieſt method of making it under every poſſible change of of the moon's rate with due accuracy and preciſion.

M. de la Lande, in his Aſtronomy, liv. 7. article 1521, obſerves that when the longitudes or A. R's of the moon are ſtrictly calculated from 12H. to 12H. as they are given in the Nautical Almanacs and other Ephemerides, you may thence deduce the horary motion for any part of this period to a great degree of preciſion;

preciſion; for if you take the 12th part of the moon's movement in longitude or A. R. for 12H. from noon to midnight, or from midnight to the ſucceeding noon, you will have the horary motion either in longitude or A. R. that took place at 6H. or 18H. For by the method of interpolation, vide article 3928, he aſcertained that in ſpite of all the irregularities of the lunar motions the 2d differences proceed at a rate that is to all ſenſe uniform even for the ſpace of 24 hours; it is evident therefore, that having obtained the horary motion, for 6 or 18Hs. by taking the $\frac{1}{12}$ of the movement for 12H. you may then have it for any other hour of that interval by an even proportion.

As the A. R's. are the only lunar motions we have occaſion to make uſe of, in this method for the longitude of places, I ſhall only conſider the manner of finding the moon's horary motion in A. R. for any required minute of any interval of 12, and thence of aſcertaining the exact quantity of the A. R. for 12H. that is to be uſed both for the correction of the interval of obſerved A. R. between the 2 meridians, and alſo for the correction of the eſtimate longitude.

Take out of the Nautical Almanac, or any other good Ephemeris, the two calculated A. R's. immediately preceding, and the two that immediately follow, the hour and minute for which you want to determine the moon's horary motion; place theſe

theſe in four ſucceſſive lines below each other, and by their ſides their three ſucceſſive differences for each 12 hours; multiply each of theſe laſt numbers by 5, taking the degrees for minutes and the minutes for ſeconds, and you will have three other numbers that will accurately denote the horary motions at the mid-intervals of the pairs they reſpectively belong to. The reaſon of multiplying by 5, &c. is merely for brevity and convenience in finding the $\frac{1}{12}$ of the motion in A. R. for 12H. for $a \times 60' \div 12 = a \times 5'$, which laſt is much the moſt conveniently and readily done.

Having thus got the horary motions for the mid-intervals of 6H. and 18H. to get them for any other hour and minute you have only to take the difference of the horary motions at the beginning and end of the period of 12Hs. that includes the hour and minute for which the rate is required, and ſay, as 12H. is to the whole difference, ſo is any other number of hours and minutes to a proportionate part; which added or ſubtracted as occaſion requires, to or from the rate of the neareſt mid-interval, gives the rate at the time demanded. Let it be required, for example, to find the moon's horary motion in A. R. for 6H. 30′. on the 5th Jan. 1789.

						H.
Jan. 4, at	12	15° 51′	× by 5	30′ 20″	horary motion 4th day at	18
5, at	0	21 55	6° 4′	31 20	horary motion 5th day at	6
5, at	12	28 11	6 16	32 20	horary motion 5th day at	18
6, at	0	34 39	6 28			

Here

Here 30′ being the exceſs of the time for which the rate is required above the laſt mid-interval, and 1′ the variation of the horary motion for 12H. ſay, 12 : 1 : : 30′ : 2″ 30‴, which added to 31′. 20″ the rate of the horary motion at 6H. gives the horary motion at 6H. 30′ = to 31′. 22″. 30‴. If we now ſuppoſe the mid-interval of the moon's paſſage over two ſucceſſive meridians, at each of which the diſtance of her enlightened limb from the ſame ſtar was obſerved to have happened at this very time, then to determine the difference of their longitudes from theſe obſervations her whole increaſe of A. R. for 12 hours, at the preciſe rate at which ſhe then moved, is required; and this quantity is had by multiplying the horary motion at 6H. 30′ by 12—thus, 31′. 22″. 30‴. × 12 = 6°. 16′. 30″.

All that ſeems now requiſite is to add a few words on the meaſure of time to be employed in the calculation of the longitude, by this method of comparing the ☽'s limb, when on two different meridians, with the ſame fixed ſtar.

As the calculations in the Nautical Almanac, of all the lunar motions, are expreſsly declared to be made for the apparent moments of noon and midnight, as deduced immediately from the ſun, and as this apparent time, about the 20th of December, varies 30″ in a day from M. ☉ time, it is evident that the change of the ☽'s A. R. for 12H. at that time, as given in the Nautical Almanac, is in fact, the change for 12H. 0′ 15″ of M. ☉ T. In this caſe therefore the A. R. gained in 15″. ſhould be deducted

ducted from the ſum of the increaſe of the ☽'s A. R. in 12H. apparent time; that the remainder may correſpond to the 2d term of the analogy (viz. 12H.) in M. ☉ T. and thus the 4th term of the proportion, namely the difference of longitudes, will alſo come out in this equable aſtronomic meaſure of time. This correction will take place wherever the diurnal difference between mean and apparent time is great enough to make any ſenſible difference in the firſt term of the proportion.

The reſult thus obtained, will however require a ſmall correction in the amount of the longitude, as found by this lunar problem.

For as 24H. M. ☉ T. amount to 360. 59. 8 ♓, and as the whole æquator comprizes but 360°. 1H. of M. ☉ T. ſhould indicate 15°. 2′. 8″. of the æquator, and as terreſtrial longitudes are counted at the rate of only 15° to an hour, the longitudes given in M. ☉ T. ſhould be corrected according to this difference, and the quantity of this correction will be readily ſhewn by the tables for converting M. ſolar into ſydereal time.

Or perhaps it may be as ready a way to reduce the 12H. of M. ſolar time into ſydereal before the proportion is made, and thus the three firſt terms in the proportion being in this meaſure of time, the fourth will conſequently come out in the ſame, and no further correction be required.

Take an Example each way:

1ſt. 8° : 12 H. M ☉ T. : : 40′ : 1 H. M. ☉ T. : but 1 H. M. ☉ T. = 1H. 0′. 9″, 83 ſydereal time.

2d. 12H. M. ☉ T. = 12H. 1′. 58′, 283 ſydereal time.

Therefore 8° : 12H. 1′. 58″, 283 : : 40′ : 1H. 0′ 9″, 83.

It is further to be obſerved that though the two corrections I have juſt ſtated are the principal ones that uſually occur in this calculation, and indeed the only ones that for meridians of ſhort intervals aſunder are ſenſibly requiſite, yet in order to diſcuſs this queſtion fully it may be neceſſary to mention ſome other ſources of irregularity, that at particular times and at places conſiderably diſtant from each other in longitude, well deſerve the notice of the attentive and ſcrupulous aſtronomer. The apparent diſk of the moon (as ſeen from the centre of the earth) being a quantity perpetually varying in its dimenſions, if its change ſhould be ſenſible in the interval between the obſervations at the firſt and ſecond meridian, it is evident that in proportion as the diameter of the moon is either contracted or expanded during this interval, the enlightened limb which ſhould be a fixed boundary of menſuration for each place will either retire farther from or be protruded towards the ſtar more under the ſecond meridian than it was under the former; and thus, independent of all other cauſes of error, vitiate the accuracy of the meaſurement. This alteration of the diſk happens from the moon's changing her abſolute diſtance from the earth during

during the interval of the obſervations. As the greateſt variation of the moon's ſemidiameter is about 16″ in a day, in this extreme caſe, under meridians that are 6H. aſunder, the correction of the diſk from this cauſe only would amount to 4″. And ſhould ſhe in the interval have changed her declination, ſo as to vary her ſemidiameter by another ſecond in the ſame direction with the former variation, then the aggregate of theſe alterations of the lunar diſk would collectively amount to five ſeconds, a quantity that would make a conſiderable error in the determination of the longitude.

The neceſſary corrections being found from the eſtimate longitude and the tables, and carefully applied, all that remains to be done is to ſtate over again the analogy mentioned in the general rule, ſubſtituting therein the corrected numbers. To render this final analogy as brief and as eaſy as poſſible, I have added a ſecond table of *aſſiſtant logarithms* for every minute of the moon's increaſe of A. R. for 12H. in which the arithmetical complement of the proportional logarithm of the quantity of the moon's increaſe of A. R. in 12H. for every change of 1′ in her rate is added to the proportional logarithm of 12H. ſo that all that is neceſſary is to change the corrected difference in time into parts of a degree, and to add its proportional logarithm to the logarithm taken out of the table, and the ſum will be the proportional logarithm of the difference of the two meridians in time.

EXAMPLE.

JANUARY 5th, 1789. The meridians of Greenwich, and of the obſervatory of Trinity College, Dublin, (eſtimated longitude 25′. 18″. weſt of Greenwich) were obſerved to apply ſucceſſively to α Aquilæ and the ☽'s firſt limb at the following intervals of A. R. in ſydereal time.

GREENWICH.		OBSERVATORY, T. C. D.	
α Aquilæ	19H. 40′. 32″. 15	α Aquilæ	19H. 40′. 52″, 8.
☽'s 1ſt limb	1. 40. 8. 50	☽'s 1ſt limb	1. 41. 26, 3.

Apparent difference of A. R. at Greenwich 5H. 59′ 36″, 35. Clock moving nearly ſydereal time.

Apparent difference of A. R. at Obſervatory, T. C. D.	6H. 0′. 33″, 5
Deduct for clock's rate	2, 6
	6. 0. 30, 9
Apparent difference of A. R. at Greenwich	5. 59. 36, 35
Appar. change of A. R. in the interval of meridians	0. 0. 54, 55
Correction from Table I.	1, 90
True change of A. R. in the interval	52, 65

Change

Change of ☽'s A. R. for 12 hours at the rate of 6H. 33, being the mid-interval of the obſervation 6°. 16′. 30	
Its aſſiſtant logarithm from Table II.	9. 7185
prop. logarithm of 52″, 65 = 13′. 9″, 7	1. 1360
	0. 8545

prop. logarithm of 25′ 9″, 6, which reduced to ſydereal time is 25′. 13″, 7 longitude weſt.

Note.—Theſe appulſes of the moon and ſtar to the meridians of Greenwich and of the Obſervatory of T. C. D. were obſerved with the excellent tranſit inſtruments that thoſe obſervatories are furniſhed with—and reduced by a mean of the five wires in the reſpective tranſit books of Drs. Maſkelyne and Uſsher.

On the Conſtruction of Table I.

As the correction of the difference of the diſtances of the moon's enlightened limb, from the ſame ſtar under different meridians, evidently depends on the interval of the meridians, combined with the moon's rate at the mid-interval of the obſervations, the table intended to facilitate this correction was conſtructed in the following manner:

Let S be the ſum of the moon's increaſe in A. R. for 12H. H 12 H. L the eſtimate longitude, D the difference of A. R.

A. R. correſponding to the moon's rate and the eſtimate longitude, and C the correction required.

Then $H : S :: L+D : D$ & $H : S :: D : C$.

Or $H-S : S :: L : D$.

Conſequently $D = \frac{S \times L}{H-S}$ or $D = \frac{S \times L}{H} \times \frac{1}{1-\frac{S}{H}} = \frac{SL}{H} \times \overline{1 + \frac{S}{H}} +$, &c.

& $\frac{D \times S}{H} = C$.

TABLE I.

Corrections of the apparent differences of the diſtances of the moon's limb from a ſtar, as obſerved on the ſame day under different meridians, in parts of ſydereal time.

Diff. Space.	Long. Time.	Increaſe of the Moon's A. R. in 12H.					
0	1	5°. 34′	6°. 4′	6°. 34′	7°. 4′	7°. 34′	8°. 4′
1	4	0, 24	0. 28	0, 33	0, 38	0, 43	0, 49
2	8	0, 47	0, 57	0, 66	0, 76	0, 86	0, 97
3	12	0, 71	0, 85	0, 99	1, 14	1. 30	1, 47
4	16	0, 96	1, 14	1, 32	1, 53	1, 73	1, 96
5	20	1, 20	1, 42	1, 65	1, 91	2, 17	2, 46
6	24	1, 45	1, 70	1, 98	2, 29	2, 60	2, 94
7	28	1, 68	1, 98	2, 31	2, 67	3, 04	3, 43
8	32	1. 92	2, 27	2, 64	3, 06	3, 47	3, 93
9	36	2. 15	2, 55	2, 97	3, 44	3, 90	4, 42
10	40	2, 38	2, 84	3, 31	3, 82	4, 34	4, 94

This

This table is to be entered at top with the moon's ſuppoſed equable rate for 12 hours aſſumed from her true rate, at the mid-interval of her paſſage from the meridian of the firſt place of obſervation to that of the ſecond; and at the ſide with the eſtimate difference of the longitudes of the places in time or motion.

N. B. In conſtructing the above table, the two firſt terms of the ſeries $\frac{S}{H}\frac{L}{}\times 1+\frac{S}{H}+$, &c. were only uſed as giving a reſult ſufficiently accurate.

A Table

A Table of aſſiſtant logarithms to facilitate the proportion that is to be made for deducing the longitude from the corrected differences of the A. R's. of the moon's enlightened limb from that of a ſtar, obſerved on the ſame day under different meridians, being

TABLE II.

′	5°	′	5°	′	6°	′	6°	′	6°
30	9.6612	50	9.6868	9	9.7097	29	9.7326	49	9.7544
31	6625	51	6880	10	7109	30	7337	50	7555
32	6638	52	6892	11	7121	31	7349	51	7565
33	6651	53	6905	12	7132	32	7360	52	7576
34	6664	54	6917	13	7144	33	7371	53	7586
35	6677	55	6929	14	7156	34	7382	54	7596
36	6690	56	6941	15	7167	35	7393	55	7607
37	6703	57	6953	16	7179	36	7404	56	7618
38	6716	58	6966	17	7190	37	7415	57	7628
39	6729	59	6978	18	7202	38	7426	58	7639
40	6742		6°	19	7213	39	7436	59	7649
41	6755	0	9.6990	20	7225	40	7448		7°
42	6767	1	7002	21	7236	41	7458	0	9.7659
43	6780	2	7014	22	7248	42	7469	1	7670
44	6793	3	7026	23	7259	43	7480	2	7680
45	6805	4	7038	24	7270	44	7491	3	7690
46	6818	5	7050	25	7282	45	7501	4	7701
47	6830	6	7062	26	7293	46	7512	5	7711
48	6843	7	7074	27	7304	47	7523	6	7721
49	6855	8	7085	28	7315	48	7533	7	7731

TABLE II. *continued.*

′	7°	′	7°	′	7°	′	8°
8	9. 7741	28	9. 7940	48	9. 8129	7	9. 8302
9	7751	29	7949	49	8139	8	8311
10	7762	30	7959	50	8148	9	8320
11	7772	31	7969	51	8157	10	8329
12	7782	32	7978	52	8166	11	8338
13	7792	33	7988	53	8176	12	8346
14	7802	34	7998	54	8185	13	8355
15	7812	35	8007	55	8194	14	8364
16	7822	36	8016	56	8203	15	8373
17	7832	37	8026	57	8212	16	8382
18	7842	38	8036	58	8221	17	8391
19	7852	39	8045	59	8230	18	8399
20	7862	40	8055		8°	19	8408
21	7871	41	8064	0	9. 8239	20	8417
22	7881	42	8073	1	8248	21	
23	7891	43	8083	2	8257	22	
24	7901	44	8092	3	8266	23	
25	7911	45	8101	4	8275	24	
26	7920	46	8111	5	8284	25	
27	7930	47	8120	6	8293	26	

The refults of the following obfervations, made by Dr. Maſkelyne and Dr. Uſher, at the obfervatories of Greenwich and Trinity College, Dublin, will tend to ſhew the advantages to be derived from this method.

		At Greenwich.		At the Obfervatory of Trinity College.		Difference of Longit. deduced.
		A. R. by the clock.	Clock d. Rate	A. R. by the clock.	Clock's d. Rate.	
1788 May 13	Procyon	7H 31′ 44″, 74	+0″, 5	7 28 43, 02	− 4″, 5	25′ 22″, 6 w
	☽ 1 L	10 31 4, 25		10 26 57, 7		
June 16	Antares	16 16 16, 30		16 14 49, 9		25 5, 0
	☽ 1 L	16 20 10, 66		16 19 41, 4		
Aug. 17	α Aquilæ	19 40 41, 94	+ 0, 5	19 39 40, 05	− 8, 0	25 48, 9
	☽ 2 L *	22 32 12, 59		22 31 59, 28		
Oct. 7	☽ 1 L	19 31 40, 38		19 34 4, 3	− 13, 0	25 10, 4
	β Aquilæ	19 44 54, 38		19 46 25, 7		
1789 Jan. 5	Aquilæ	19 40 32, 15	+ 0, 6	19 40 52, 8	+ 11, 0	25 13, 7
	☽ 1 L	1 40 8, 50		1 41 26, 3		
Jan. 8	Aldebaran	4 23 57, 12		4 25 21, 4	+ 10, 0	24 50, 2
	☽ 1 L	4 32 57, 90		4 35 27, 6		
Feb. 5	Aldebaran	4 23 44, 22	− 0, 8	4 24 38, 9	+ 15, 6	25 12, 0
	☽ 1 L	5 4 48, 82		5 6 49, 6		
Feb. 7	☽ 1 L	7 12 39, 80	− 0, 7	7 15 15, 7	+ 15, 0	25 16, 6
	Pollux	7 32 16, 68		7 33 44, 9		
Feb. 9	Procyon	7 28 7, 60	− 0, 4	7 30 6,	+ 14, 5	24 57, 5
	☽ 1 L	9 18 44, 98		9 21 48, 2		
Sept. 27	☽ 1 L	19 38 47, 00	− 0, 7	19 38 7, 1	− 20, 0	25 15, 5
	β Aquilæ	19 44 50, 42		19 43 16, 3		
Nov. 26	α Aquilæ	19 40 4, 92	+ 0, 3	19 39 0, 29	− 20, 0	25 3, 5
	☽ 1 L	23 46 40, 48		23 46 20, 3		
Dec. 24	☽ 1 L.	0 13 25, 72	− 0, 6	0 13 16, 9	− 17, 8	25 10, 0
	Aldebaran	4 23 15, 98		4 22 15, 8		
Dec. 25	☽ 1 L	7 0 4, 72	− 0, 6	0 59 38, 7	− 17, 8	25 9, 8
	Aldebaran	4 23 15, 06		4 21 57, 0		
Dec. 31	☽	6 27 31, 28	− 0, 6	6 27 33, 27	− 18, 0	24 50, 6
	Pollux	7 31 44, 08		7 30 42, 8		

☞ *For * ſee next Page.*

* This obſervation of the ſecond limb gives the difference of longitude greater than the obſervations of the preceding limb; which is to be attributed to the difference of the teleſcopes. — The Greenwich tranſit inſtrument gives a leſs diameter of the ſun than the tranſit inſtrument of the obſervatory of T. C. D. and the effect of this difference of inſtruments is to leſſen the longitudes deduced by the above method from obſervations of the firſt limb, and to increaſe thoſe deduced from the ſecond limb. Conſequently to uſe this method to moſt advantage a mean of reſults deduced from obſervations of both limbs ought to be taken.

On the METHOD *of taking* RADICALS *out of* EQUATIONS. *By* Mr. D. MOONEY, *A. B. Trinity College, Dublin. Communicated by* WHITLEY STOKES, *M. D. F. T. C. D. and M. R. I. A.*

Read June 18th, 1796.

AMONG the rules delivered by the incomparable Sir Iſaac Newton for the Reduction of Equations, the following is a principal one:

" Si cui ſurdæ quantitati irreducibili litera involvatur ad cujus " dimenſiones, æquatio ordinanda eſt, cæteri omnes termini ad " contrarias partes, cum ſignis mutatis transferendi ſunt, & utra- " que pars æquationis in ſe ſemel multiplicanda, ſi radix quadra- " tica ſit, vel bis ſi ſit cubica."

If the letter be involved in a ſingle ſurd, the operation is eaſily performed by ſimple involution; but if in two or more ſurds, of the ſame or different dimenſions, or if there be a number of radical quantities involved in the terms of the equation, the operation for clearing ſuch an equation from radicals, is ſomewhat more difficult.

In

In the 97th Section of his Analyſis, Doctor Hales ſhews the method of taking quadratic ſurds out of an equation, provided the number of terms be not greater than four, but if there be a fifth term, whether rational or ſurd, he is of opinion that the equation cannot, by that method, be cleared from ſurds. Were this the caſe, we would have no other alternative, than to recur to the method of Monſieur Fermat, by feigning the ſurds equal to an aſſumed letter, and thence by means of as many ſimple equations, as there are ſurds, to take theſe letters out of the equation; but this is a work of ſo much labour, that it is ſufficient to deter a perſon ſlightly acquainted with algebra. However, by conſidering the nature of the ſurds that ariſe after involution, it will readily appear that there is no ſuch limit, nor any need of recurring to an operation ſo laborious.

Let the equation propoſed conſiſt of five quadratic ſurds, if theſe can be rendered rational, four quadratics and a rational may be reduced at leaſt with the ſame eaſe,

$$\sqrt{a} + \sqrt{b} = \sqrt{c} + \sqrt{d} + \sqrt{f},$$

it is plain, that any equation, conſiſting of five ſurds, may be reduced to this form, thence after involution will ariſe the feweſt number of *ſurd* rectangles (Doctor Saunderſon ſhews in his algebra that if two quantities be irrational, their product will be ſo too) for if the equation was divided into parts of one and four ſurds, the reſult would have ſix ſurd rectangles, and from the former poſition there will ariſe but four.

By

By ſquaring the ſides of the equation propoſed, we will have,

$$a+b+2\sqrt{ab}=c+d+f+2\sqrt{cd}+2\sqrt{cf}+2\sqrt{df}.$$

If all the combinations that can be made out of the trinomial $\sqrt{c}+\sqrt{d}+\sqrt{f}$ be obſerved, which are only three, we will ſee, that the ſuffixed quantities of every two of theſe admit one common diviſor; place then any two of theſe combinations at the ſame ſide, and the reſt of the terms at the other, and aſſuming the rational quantities collected $=p$ we have,

$$p+2\sqrt{ab}-2\sqrt{cd}=2\sqrt{cf}+2\sqrt{df}, \text{ and by ſquaring}$$

$$p^2+4ab+4cd+4p\sqrt{ab}-4p\sqrt{cd}-8\sqrt{abcd}=4cf+4df+8f\sqrt{dc}.$$

Of theſe ſurd rectangles, it will appear, that two coaleſce, i. e. have the ſame ſuffixed quantity, and the ſuffixed quantities of the others admit a common diviſor. By placing the rationals collected $p^2+4ab+4dc-4cf-4df=q$, and the coefficient $8f-4p=r$, we have $4p\sqrt{ab}-8\sqrt{abcd}=r\sqrt{dc}-q$, and ſquaring,

$16p^2ab+64abcd-64pab\sqrt{cd}=r^2dc+q^2-2qr\sqrt{cd}$: now putting the rationals $=f$, and the coefficient, $64pab-2qr=t$, the equation will ſtand, $f=t\sqrt{cd}$, and ſquaring, $f^2=t^2cd$, which latter equation is free from ſurds. It is plain that aſſuming letters for the rationals, is only for brevity, and no way affects the ſurds. Thus it will appear, how an equation, involving five quadratic ſurds, is rendered rational, by the ſimple rules of involution and tranſpoſition.

Having

HAVING thus ſhewn, that this method has more latitude than has been generally imagined, I ſhall endeavour to evince the truth of it in the caſe of a ſexinomial; thereby demonſtrating its univerſality, and ſhewing how the ſurds, one by one, vaniſh, notwithſtanding the enormous appearance of ſurd rectangles at firſt; for the number of ſurd rectangles, ariſing from the involution of a multinomial ſurd quantity to the ſquare, is always equal to the ſum of the natural numbers between 0 and the number of the parts connected by the ſigns + or −, and therefore rapidly encreaſes.—Vide Saunderſon's Alg. Tom. 2, Section 422, (ſub finem;) & Simpſon's Alg. Chapter on Combinations.

LET there be propoſed the equation, conſiſting of a rational and five quadratic ſurds, $x + \sqrt{a} + \sqrt{b} - \sqrt{c} - \sqrt{d} - \sqrt{f} = 0$.

AFTER tranſpoſition, the equation muſt either have two parts at one ſide, and four at the other, in which caſe, after involution, there will be ſeven ſurd rectangles; or one part at one ſide, and five at the other, from whence would ariſe, after involution, ten ſurd rectangles; or finally, three parts at each ſide of the equation, from whence, after involution, reſult ſix ſurd rectangles, i. e. three at each ſide. Let us take the equation from whence the leaſt number of ſurd rectangles reſult;

$$x + \sqrt{a} + \sqrt{b} = \sqrt{c} + \sqrt{d} + \sqrt{f}$$

ſquared $x^2 + \overline{a + b} + 2x\sqrt{a} + 2x\sqrt{b} + 2\sqrt{ab} = c + d + f + 2\sqrt{cd} + 2\sqrt{cf} + 2\sqrt{df}$.

LET

Let the rationals collected $= g$, and transferring to the other ſide as well the rationals as the ſimple quadratic $2 \times \sqrt{b}$, the equation will be $2 \times \sqrt{a} + 2\sqrt{ab} = 2\sqrt{cd} + 2\sqrt{cf} + 2\sqrt{df} - 2 \times \sqrt{b} - g$.

For brevity ſake I ſhall hereafter aſſume letters for the rationals of the equations, and transfer each ſurd as it comes out to a ſimilar one wherever it is found, annexing the ſign according to the ſide it is placed at; ſquaring the above equation we have

$$\begin{array}{l} b + 8 \times a\sqrt{b} = i \mid 8c\sqrt{df} + 8d\sqrt{cf} - 8 \times \sqrt{bcd} - 4g\sqrt{cd} - 8 \times \sqrt{bcf} - 8 \times \sqrt{bdf} \\ \quad -4g \times \sqrt{b} \quad -4g\sqrt{df} - 4g\sqrt{cf} \quad +8f\sqrt{cd} \end{array}$$

Here then we have an equation free from the ſurd $\sqrt{a}$ and ſince the coefficients of the ſurds can by no means affect the poſſibility of clearing it, and we are ſo far only concerned, I ſhall omit them, and ſubſtituting k for the rationals $i - b$, the equation will be $\sqrt{b} + \sqrt{bcd} + \sqrt{bcf} + \sqrt{bdf} = \sqrt{df} + \sqrt{cf} + \sqrt{cd} - k$ and ſquaring.

$$\begin{array}{l} \overline{l + 2b\sqrt{cd} + 2b\sqrt{cf} + 2b\sqrt{df}} \quad = m + 2f\sqrt{cd} + 2d\sqrt{fc} - 2k\sqrt{df} \\ \quad + 2bf\sqrt{cd} + 2bd\sqrt{cf} + 2bc\sqrt{df} \quad -2k\sqrt{cd} - 2k\sqrt{fc} + 2c\sqrt{df}, \end{array}$$

whence neglecting coefficients after uniting the ſurds; we have $\sqrt{cd} + \sqrt{cf} = \sqrt{df} - n$. Here we have exterminated the ſurd $\sqrt{b}$, and by each ſucceeding operation we take away one more, always adhering to the rules to transfer to the ſame ſide all thoſe ſurds whoſe ſuffixed quantities involve the ſame letter; from whence alſo it follows that the number of involutions will be plus one than the number of ſurds. In the ſecond ſtep there were eleven ſurds with rationals, and in the next tho' twelve appear;

they can be reduced to three and a rational, whence the ſimplification is manifeſt: The ſame I have tried in a ſeptinomial, and the reſult was agreeable to the former; though the third involution, produced twenty-nine ſurd rectangles beſides rationals.

The example propoſed by Newton, where he mentions M. Fermat's method, will readily prove that the method juſt laid down ſhews the connection of the parts of the equation much better and is much more brief, the whole being carried on in one ſingle equation; that example is an equation conſiſting of a cubic ſurd, two quadratics and a rational, and which Sir Iſaac has given us without the operation. Doctor Hales in his Analyſis, 98th Section, has given the operation where even the ſubſtituted letters riſe to the cubic dimenſion. I ſhall now ſubjoin the operation according to the method now propoſed:

$\sqrt{ay} - \sqrt{a^2 - ay} - 2a = \sqrt[3]{ay^2}$ which cubed and collecting ſimilar terms becomes $-14a^3 + \overline{15a^2 - 2ay}\sqrt{ay} - \overline{13a^2 - 2ay}\sqrt{a^2 - ay} + 12a^2 \sqrt{ay - y^2} = ay^2$; aſſuming $\overline{15a^2 - ay} = p$ and $\overline{13a^2 + 2ay} = q$ by tranſpoſition we have,

$p\sqrt{ay} + 12a^2\sqrt{ay - y^2} = ay^2 + 14a^3 + q\sqrt{a^2 - ay}$ and ſquaring,

$p^2 ay + 144\overset{5}{ay} - 144\overset{4\,2}{ay} + 24p\overset{2}{ay}\sqrt{a^2 - ay} = \overset{2\,4}{ay} + 196\overset{6}{a} + q\overset{2\,2}{a} - q\overset{1\,2}{ay} + 28\overset{4\,2}{ay} + 2q\overset{3}{ay} + 28aq\sqrt{a^2 - ay}.$

whence

whence tranſpoſing and ſimplifying we have,

$$\overline{p^2+q^2} : ay + 144ay^{5} - 172ay^{4\,2} - 196a^{6} - ay^{3\,4} - qa^{3\,2} = \begin{matrix} +2qay \\ +28aq^{3}\sqrt{a^2-ay} \\ -24apy^{2} \end{matrix}$$

which latter equation has but one ſurd, whence for $p \cdot q \cdot p^2$ and q^2 ſubſtituting their values and connecting the terms we have after dividing all by a^2

$$-y^{4} + 8ay^{3} - 184ay^{2\,2} + 486ay^{3} - 365a^{4} = \overline{74ay^{3} - 304ay^{2} + 364a^{3} + 4y^{3}}$$

$: \sqrt{a^2\,ay}$ which equation ſquared and transformed into an original equation gives an equation free from ſurds the ſame as Doctor Hales's final equation.

$$y^{8} + 1008ay^{2\,6} - 1464ay^{3\,5} - 2762ay^{4\,4} + 3680ay^{5\,3} + 2916ay^{6\,2} - 972ay^{7} + 729a^{8} = 0.$$

By the ſame management we may take away the aſymmetry of an equation having ſurds of a more intricate nature.

Let there be propoſed the equation conſiſting of a cubic ſurd and two biquadratics $\sqrt[4]{a} + \sqrt[4]{b} = \sqrt[3]{c}$.

Involve both ſides to the cube and the equation will then ſtand,

$$\sqrt[4]{a^3} + 3\sqrt[4]{ab^2} + 3\sqrt[4]{a^2b} + \sqrt[4]{b^3} = c.$$

of theſe ſurds we may obſerve that the product of two pairs

will give a ſimple quadratic, placing at the ſame ſide thoſe pairs the equation will ſtand,

$\sqrt[4]{a^3} + 3\sqrt[4]{ab^2} = c - 3\sqrt[4]{a^2b} - \sqrt[4]{b^3}$ and ſquaring this equation

$a\sqrt{a} + 6a\sqrt{b} + 9b\sqrt{a} = \sqrt{c} + 9a\sqrt{b} + b\sqrt{b} - 6c\sqrt[4]{a^2b} - 2c\sqrt[4]{b^3} + 6b\sqrt{a}$

Let the terms be collected uniting ſuch ſurds as admit it, and ſubſtituting letters for the coefficients $\overline{3a+b} = y$

$-3b-a = z$

the equation will now be $6c\sqrt[4]{a^2b} + 2c\sqrt[4]{b^3} = c^2 + y\sqrt{b} - z\sqrt{a}$

whence by ſquaring $36ca\sqrt{b} + 24cb\sqrt{a} + 4cb\sqrt{b} = \sqrt{c} + y\sqrt{b} + z\sqrt{a} + 2cy\sqrt{b} - 2cz\sqrt{a} - 2yz\sqrt{ab}$.

Let $36ca + 4cb - 2cy = v$

$c^2 + yb + za = x$

$24cb + 2cz = t$

The equation will then by tranſpoſition ſtand thus,

$v\sqrt{b} + t\sqrt{a} = x - 2yz\sqrt{ba}$ and ſquaring

$v^2b + ta + 2vt\sqrt{ab} = x - 4yzx\sqrt{ba} + 4yzba$ let the rationals $= r$ and the coefficient $2vt + 4yzx = s$ and the equation will be $s\sqrt{ab} = r$ and ſquaring $s^2ab = r^2$ where all the terms are rational.

NEARLY

NEARLY ſimilar is the management of three biquadratic ſurds, by all which it will appear that this method is much ſhorter than M. Fermat's; the principal care to be taken is to keep at the ſame ſide two ſurds whoſe product will give a ſimple quadratic, and then uniting the terms that will admit of it proceed as before by involution and tranſpoſition.

WHEN fractions having ſurds in their denominators occur, it is expedient to remove the ſurds out of the denominator by multiplication, this is uſually done by the multiplication of the denominator taken as a binomial or reſidual; if there be four quadratic ſurds this is generally ſuppoſed the limit, and that if a fifth term be added whether rational or not, the denominator cannot be rendered rational, but ſince the binomial or reſidual here affords the ſame convenience as the tranſpoſition in equations, a repeated multiplication will clear the denominator of radicality. True it is that after multiplication by a binomial, if the denominator be reſolved into parts of one and four ſurds, there will come out ſix ſurds and in no caſe leſs than four and a rational, however by continuing the operation a little farther the ſimplification will appear,

m &c. - - - - - - - - - - - - -

$\sqrt{a+\sqrt{b+\sqrt{c+\sqrt{d+\sqrt{e}}}}} \times \sqrt{a}+\sqrt{b}-\sqrt{c}-\sqrt{d}-\sqrt{e}$ the denominator which is the multiplier being reſolved into parts of two

and

and three ſurds, in which caſe fewer ſurds will come out in the product after uniting ſuch as admit of it, than if the denominator were reſolved into parts of four and one, by retaining at the ſame ſide of the binomial thoſe ſurds whoſe quantities under the radical ſign have a common diviſor, in the next multiplication their product coaleſce and may be united, ſo that after four multiplications the denominator is freed from radicality as will beſt appear by example,

$$\sqrt{a+\sqrt{b+\sqrt{c+\sqrt{d+\sqrt{e}}}}} \times \sqrt{a+\sqrt{b-\sqrt{c-\sqrt{d-\sqrt{e}}}}}$$

$$+a \;+\sqrt{ab}+\sqrt{ac}+\sqrt{ad}+\sqrt{ae}+\sqrt{bc}+\sqrt{bd}+\sqrt{be}-\sqrt{cd}-\sqrt{ce}-\sqrt{ed}$$
$$+b \;+\sqrt{ab}-\sqrt{ac}-\sqrt{ad}-\sqrt{ae}-\sqrt{bc}-\sqrt{bd}-\sqrt{be}-\sqrt{cd}-\sqrt{ec}-\sqrt{ed}$$
$$-c$$
$$-d$$
$$-e$$

$$a+b-c-d-e+2\sqrt{ab} \;\; * \; * \; * \; * \; * \; * \;\; -2\sqrt{cd}-2\sqrt{ce}\,2\sqrt{cd}$$

Let all the rationals equal r and the product will be

$$r+2\sqrt{ab}-2\sqrt{ce}-2\sqrt{cd}-2\sqrt{de}$$

$$r+2\sqrt{ab}-2\sqrt{ce}-2\sqrt{cd}-2\sqrt{ed} \times r+2\sqrt{ab}-\sqrt{ce}+2\sqrt{cd}+2\sqrt{de}$$

$$r \;+2r\sqrt{ab}-2r\sqrt{ce}-2r\sqrt{cd}-2r\sqrt{de}-4\sqrt{abce}-4\sqrt{abcd}-4\sqrt{abde}$$
$$4ab+2r\sqrt{ab}-2r\sqrt{ce}+4e\sqrt{cd}+4c\sqrt{de}-4\sqrt{abce}+4\sqrt{abcd}+4\sqrt{abcde}$$
$$4ce \qquad -4d\sqrt{ce}+2r\sqrt{cd}-4c\sqrt{de}$$
$$4cd \qquad -4d\sqrt{ce}-4e\sqrt{cd}+2r\sqrt{de}$$
$$4de$$

$$r^2+4ab+4ce-4cd-4de+4r\sqrt{ab}-4r-8d\sqrt{ce}-8\sqrt{abce}$$

Let

LET all the rationals $= p$ and the coefficient $- 4r - 8d = q$ and the product will now be $p + 4r\sqrt{ab} - q\sqrt{ce} - 8\sqrt{abce}$ by obſerving the ſame rules and multiplying by $p + 4r\sqrt{ab} + q\sqrt{ce} + 8\sqrt{abce}$ the product will have but one ſurd.

$$\frac{p + 4r\sqrt{ab} - q\sqrt{ce} - 8\sqrt{abce} \times p + 4r\sqrt{ab} + q\sqrt{ce} + 8\sqrt{abce}}{}$$

will give $p^2 + 16r^2ab - q^2ce - 64abce + 8rp - 16qce\sqrt{ab}$ now 'tis plain that by one multiplication more the denominator is free from all radicals.

On the PRIMITIVE STATE *of the* GLOBE *and its* SUBSEQUENT CATASTROPHE. By RICHARD KIRWAN, *Esq; L.L.D. F.R.S. and M.R.I.A.*

Read Nov. 19th 1796.

IN the inveſtigation of paſt facts dependent on natural cauſes, certain laws of reaſoning ſhould inviolably be adhered to. The firſt is, that no effect ſhall be attributed to a cauſe whoſe *known* powers are inadequate to its production. The ſecond is, that no cauſe ſhould be adduced whoſe exiſtence is not proved either by actual experience or approved teſtimony. Many natural phænomena have ariſen or do ariſe in times or places ſo diſtant, that well conditioned teſtimony concerning them cannot without manifeſt abſurdity be rejected. Thus the inhabitants of the Northern parts of Europe, who have never felt earthquakes nor ſeen volcanos, muſt nevertheleſs admit, from mere teſtimony, that the firſt *have* been, and that the ſecond *do actually* exiſt.

THE third is, that no power ſhould be aſcribed to an alleged cauſe but thoſe that it is known by actual obſervation to poſſeſs in appropriated circumſtances.

To theſe laws I mean ſtrictly to conform in the ſubſequent inquiry, and on this conformity to reſt its merits. To them I ſhall appeal in examining the various ſyſtems I may have occaſion to mention.

To thoſe who may regard this inquiry as ſuperfluous, and conſider the actual ſtate of the globe as alone intitled to philoſophical attention, I ſhall beg leave to obſerve that its original ſtate is ſo ſtrictly connected with that which it at preſent exhibits, that the latter cannot be properly underſtood without a retroſpect to the former, as will amply be ſhewn in the ſequel. Moreover recent experience has ſhewn that the obſcurity in which the philoſophical knowledge of this ſtate has hitherto been involved, has proved too favourable to the ſtructure of various ſyſtems of atheiſm or infidelity, as theſe have been in their turn to turbulence and immorality, not to endeavour to diſpel it by all the lights which modern geological reſearches have ſtruck out. Thus it will be found that geology naturally ripens, or (to uſe a mineralogical expreſſion) *graduates* into religion, as this does into morality.

So numerous indeed and ſo luminous have been the more modern geological reſearches, and ſo obviouſly connected with the object we have now in view, that ſince the obſcuration or obliteration of the primitive traditions, ſtrange as it may appear, no period has occurred ſo favourable to the illuſtration of the

the original ſtate of the globe as the preſent, though ſo far removed from it. At no period has its ſurface been traverſed in ſo many different directions, or its ſhape and extent under its different modifications of earth and water been ſo nearly aſcertained, and the relative denſity of the whole ſo accurately determined, its ſolid conſtituent parts ſo exactly diſtinguiſhed, their mutual relation, both as to poſition and compoſition, ſo clearly traced, or purſued to ſuch conſiderable depths as within theſe laſt twenty-five years. Neither have the teſtimonies that relate to it been ever ſo critically examined and carefully weighed, nor conſequently ſo well underſtood, as within the latter half of this century.

The introduction of teſtimony into reſearches merely philoſophical has been, I am well aware, objected to by many, but in the preſent caſe the objection evidently originates in inattention to its object. All philoſophical reſearches are grounded either on experiment or obſervation ſingly or jointly, and the conſequences clearly deducible from them. Where recourſe cannot be had to experiment, as in the preſent caſe, there obſervation ſingly muſt be reſorted to, but as objects even of obſervation are not of daily occurrence, and many of them muſt have exiſted at diſtant intervals of time and place, recourſe muſt be had to its *records* and conſequently to teſtimony. Aſtronomy furniſhes us with a caſe in point. This is a ſcience purely philoſophical, yet aſtronomers have never heſitated to admit the obſervations of an Hipparchus

or a Ptolemy. In effect paſt geological facts being of an hiſtorical nature, all attempts to deduce a complete knowledge of them merely from their ſtill ſubſiſting conſequences, to the excluſion of unexceptionable teſtimony, muſt be deemed as abſurd as that of deducing the hiſtory of ancient Rome ſolely from the medals or other monuments of antiquity it ſtill exhibits, or the ſcattered ruins of its empire, to the excluſion of a Livy, a Salluſt or a Tacitus. That great changes have taken place on the ſurface of the globe ſince the commencement of its exiſtence, changes that for ſome thouſand years have not been repeated, is allowed on all hands. What then ſhould render theſe facts and the circumſtances attending them unſuſceptible of teſtimony? not ſurely their improbability or diſcrepance with actual obſervation, ſince their reality is confeſſed by all; with reſpect to *ſome* of them I can think of no reaſon but one, and that indeed at the firſt bluſh ſufficiently plauſible, namely that their exiſtence preceded that of the human ſpecies; this certainly proves that the knowledge of the hiſtorian that relates them (ſuppoſing him to have any) was not as to ſuch facts obtained by human means. But if in a ſeries of facts diſcovered by an inveſtigation to which the witneſs was an utter ſtranger, an exact agreement with the relation of the hiſtorian be diſcerned, not barely as to the ſubſtance of the facts but even as to the order and ſucceſſion of their exiſtence, in ſuch caſe it muſt be acknowledged that the relation is *true*, let the knowledge of the hiſtorian have been obtained

tained how it may. If its primary ſource cannot be human it muſt have been ſupernatural, and moſt aſſuredly worthy of credit even in ſuch inſtances as have not as yet been corroborated by obſervation, or perhaps are incapable of ſuch additional proof. Now ſuch an account of the primæval ſtate of the globe and of the principal cataſtrophes it anciently underwent, I am bold to ſay Moſes preſents to us, and I make no doubt of demonſtrating in the following Eſſays.

FIRST ESSAY

ON THE

PRIMÆVAL STATE OF THE GLOBE.

THE firſt remarkable fact that preſents itſelf to our notice on conſidering the primitive ſtate of the globe is, that its ſuperficial parts, at leaſt to a certain depth, muſt have originally been in a ſoft or liquid ſtate. This fact is inferred from the ſhape it at preſent exhibits, which, as aſtronomers tell us, is that of a ſphœroid compreſſed at the poles, the polar diameter being found ſeveral miles ſhorter than the æquatorial; nor is it at the poles only that this compreſſion is obſervable, but in all the higher degrees of latitude, nearly in proportion to their proximity to the poles. This ſhape it evidently could not aſſume unleſs to a certain depth its ſuperficial parts were in a ſoft or liquid ſtate. Some *geological* obſervations alſo indicate that its component parts, even thoſe

thoſe that are at preſent the moſt ſolid, were originally in a ſoft ſtate. Thus in the mountains of Quedlicæ and Portfiœllet in Norway, which conſiſt of an argillaceous pudding ſtone, the ſiliceous pebbles it contains are obſerved to be compreſſed to the thickneſs of about $\frac{1}{4}$ of an inch in the lower parts of the mountains, but to increaſe in ſize and roundneſs in proportion as their ſituation is higher.—1. Bergm. Erde Beſch. 182. and in the *Vivarois* the loweſt ſtrata of primitive limeſtone have been found of the thickneſs of only $\frac{1}{10}$ of an inch, but in proportion to their heighth in the mountain their thickneſs increaſes, until at its ſummit it arrives to thirty or forty feet. 1. Soulavie, 178. Mr. Ferner made the ſame obſervation in England*, but it is needleſs to inſiſt further on this point, as it is now generally allowed.

With reſpect to the interior and more central parts, they having been hitherto inacceſſible, nothing can be determined from immediate obſervation, but we may collect with ſufficient certainty, and it is now generally acknowledged, that at the time of the creation and for many centuries after they contained immenſe empty caverns, and conſequently conſiſted of materials ſufficiently ſolid to reſiſt the preſſure of the enormous maſs of liquid ſubſtance placed over them.

The liquidity thus proved to exiſt in the more ſuperficial parts of the globe, comprehending even thoſe that are now moſt ſolid, muſt

* 1 Roz. 8vo. p. 64. and Gruber in Carniola. Phy. Arbeit. 2d Stuck. 3.

muſt have proceeded either from igneous fuſion or ſolution in water. The hypotheſis of igneous fuſion wars with every notion which experiment has taught us to form either of fire or its fuel, or the properties and appearances of the various ſubſtances ſuppoſed to be ſubjected to it, as I have ſhewn at large in a former diſſertation contained in the Tranſactions of this Academy; the latter perfectly accords, and much more perfectly than I was then aware of, with all the properties and characters that all the ſolids now known exhibit, thoſe confeſſedly of volcanic origin ſolely excepted.

The difficult ſolubility in water of moſt of the ſolids which the globe at preſent exhibits, and the immenſe quantity of that fluid requiſite to effect their ſolution, forms the only difficulty that has hitherto embarraſſed geologiſts, though it has prevented ſcarce any of them from admitting that ſolution. Moſt of them have ſuppoſed that at that early period ſome menſtruum exiſted capable of effecting it. This difficulty however proceeds ſolely from inattention to the firſt demonſtrated fact, namely, that the globe at its origin, at leaſt to a certain depth, was a liquid maſs; therefore the ſolids that at preſent compoſe it were not originally in a ſolid ſtate, whoſe converſion into a ſtate of liquidity would certainly require more water than is known to exiſt, but were at the very commencement of their exiſtence in that ſtate of minute diviſion which aqueous ſolution requires, but which no known exiſting quantity of that fluid would be able to effect.

Now

Now it is a well known chymical fact that leſs of any menſtruum is requiſite to keep a ſolid ſubſtance in ſolution, at leaſt for a ſhort time, than originally to diſſolve it.

Yet if the quantity of aqueous fluid requiſite even to keep the maſs of ſolids in ſolution were too ſmall, as poſſibly it may have been, this would only haſten the *ſecond* general fact to which I now proceed, namely, the cryſtallization, precipitation and depoſition of theſe ſolids. But before I enter on this event it will be neceſſary to conſider more particularly the ſtate of this original chaotic fluid.

The water which conſtituted this menſtruum being in a liquid ſtate muſt have been heated at leaſt to thirty-three degrees, and poſſibly much higher. Secondly, it contained the eight generic earths, all the metallic and ſemi-metallic ſubſtances now known, the various ſimple ſaline ſubſtances, and the whole tribe of inflammables, ſolid and liquid, which are of a ſimple nature, variouſly diſtributed, forming upon the whole a more complex menſtruum than any that has ſince exiſted, and conſequently endued with properties very different from any with which we have been ſince acquainted.

Hence elementary fire or the principle of heat muſt have been coeval with the creation of matter, and the general properties of gravitation and elective attraction may be ſuppoſed of equal date.

The

The proportion of the different materials contained in the chaotic fluid to each other may be ſuppoſed upon the whole nearly the ſame as that which they at preſent bear to each other, the ſiliceous earth being by far the moſt copious, next to that the ferruginous, then the argillaceous and calcareous, laſtly the magneſian, barytic, Scottiſh and Iargonic, in the order in which they are named, the metallic ſubſtances (except iron) moſt ſparingly; in particular parts however of this polygenous fluid a very different proportion muſt have obtained (as in ſome parts of the globe) ſome ſpecies of earth or metal, &c. have evermore been found more copious than in others. Some geologiſts, as Buffon, and of late Doctor Hutton, have excluded calcareous earth from the number of the primæval, aſſerting the maſſes of it we at preſent behold to proceed from ſhell fiſh. But in addition to the unfounded ſuppoſition, that ſhell fiſh or any animals poſſeſs the power of producing any ſimple earth, theſe philoſophers ſhould have conſidered that before the exiſtence of any fiſh the ſtony maſſes that incloſe the baſon of the ſea muſt have exiſted, and among theſe there is none in which calcareous earth is not found. Of this circumſtance indeed Buffon was ignorant, the analyſes that prove it being unknown to him. Doctor Hutton endeavours to evade this argument by ſuppoſing the world we now inhabit to have ariſen from the ruins and fragments of an anterior, and that of another ſtill prior, without pointing at any original. If we are thus to proceed *in infinitum* I ſhall not pretend to follow him, but if he ſtops anywhere, unleſs he alſo ſuppoſes his primi-

tive globe abſolutely different from that which we inhabit, (and with ſuch I do not meddle) he will find the ſame argument equally to occur.

In a fluid conſtituted as that juſt mentioned, it is evident, from the laws of elective attraction, that the various ſolids diffuſed through it muſt ſoon have coaleſced in various proportions according to the laws of this attraction and the preſence or proximity of the ingredients, and thus have cryſtallized into different groups, which deſcended to and were depoſited on the inferior ſolid kernel of the globe. In thoſe tracts in which the ſiliceous, and next to it the argillaceous earth moſt abounded, (and ſuch tracts appear to have been by far the moſt extenſive) granite and gneiſs appear to have been firſt formed, and their formation may thus be explained: Both theſe rocks conſiſt of quartz, felſpar and mica, in a variable proportion, but the quartz and felſpar are generally the moſt copious. Theſe ſtones are themſelves compoſed of ſiliceous and argillaceous particles, and particularly the firſt, principally of ſiliceous, the two latter admitting alſo the argillaceous and a ſmall proportion of the calcareous; the magneſian and in ſome inſtances of the barytic. Now of theſe earths, *that* ſhould coaleſce firſt, which with an equally ſmall affinity to water was at the ſame time moſt plentifully contained in it, its particles being more within the reach of each other's attraction. Hence we may conclude that the quartz firſt cryſtallized, ſcarce ever indeed perfectly, from the diſturbance that muſt

muſt have occurred in ſuch an immenſe body of an heterogeneous fluid, nor perfectly pure by reaſon of its affinity to argil and calx. Next to this felſpar, containing a ſmaller proportion of ſilex and a larger of the other earths, proportions which, from their eaſy fuſibility, alſo appear to exhibit the *maximum* of attraction of theſe earths to each other when ſilex and argill prevail, muſt have cryſtallized next, and laſtly the mica, a ſtone in which the proportion of ſilex to argil is ſtill ſmaller. The portion of water diſengaged from theſe earths gradually aſcended and made room for new ſhoots, which attaining the foregoing before they were perfectly hardened adhered to them cloſely, and thus at laſt vaſt uniform blocks were formed; where the ſhoots had not attained a certain degree of hardneſs, or the ſofter ingredient, viz. the mica abounded, the gneiſs was formed; and where the proportions requiſite to form felſpar were deficient, the other granitic ingredients being preſent, ſhiſtoſe mica was formed. Hence we may underſtand how it has happened that gneiſs ſhould ſometimes be found in granite*, and ſometimes maſſes of granite in the midſt of gneiſs, and why in mountains, granite, gneiſs and ſhiſtoſe mica frequently alternate with each other. Charpent. 390.

As the fluid from which theſe cryſtallized granitic maſſes ſubſided was of the moſt heterogeneous kind it is not to be wondered at that various metallic ſubſtances, and particularly iron, and even ſome traces of carbon and plumbago, ſhould ſometimes occur in them. 2 Sauſs. 451. 2 Bergm. Jour. 1790. 532.

* Werner kurze Claſſif. 9, 10.

In other tracts where the ſame earths occurred, but not in the proportions fitted to produce granitic ingredients, other maſſes of the ſiliceous genus, as ſiliceous ſhiſtus, ſiliceous porphyries, jaſpers, &c. were formed by a leſs perfect and confuſed cryſtallization.

In various places argillites, hornblende ſlates, ſerpentines and other primæval ſtones of various denominations muſt have ariſen according to the predominant proportion of their ingredients by a more or leſs perfect or partial cryſtallization.

Metallic ſubſtances (all of which I ſuppoſe to have originally exiſted in their complete metallic ſtate) and particularly iron, of all others the moſt copious, muſt in ſundry inſtances have met and combined with ſulphur, the ſubſtance to which all and particularly iron has the greateſt affinity, and thus pyritous ſubſtances and ſulphurated ores originated. Petrol, ſpecifically lighter indeed than water, but involved in the chaotic fluid, meeting ſulphur to which it has an affinity, with it formed a liquid ſpecifically heavier, which gradually involved and was abſorbed by carbonic particles which were thus collected and precipitated.

It is a fact at preſent well eſtabliſhed, that in the act of cryſtallization a very conſiderable degree of heat is generated. Judging then by analogy, how great then muſt have been the heat produced by the cryſtallization of ſuch immenſe quantities of ſtony maſſes as took place at this period, the immediate effect of

of which muſt have been an enormous and univerſal evaporation, ſweeping over the ſurface of the heated fluid according to the inequality of its diffuſion and the cauſes that produced it in various tracts.

The heat thus produced muſt have been ſtill farther increaſed in conſequence of an event which naturally reſulted from the degree at firſt excited. For in conſequence of the evaporation the quantity of the chaotic fluid (the univerſal menſtruum), as alſo its ſpecific gravity, were diminiſhed, and thus the ſubſtances contained in it (of which it was not the moſt natural ſolvent) were ſtill more diſpoſed to precipitation, as uſually happens in ſuch caſes; thus then the ferruginous particles naturally not ſoluble while in this metallic ſtate in any fluid, and of which immenſe quantities exiſted, were rapidly and copiouſly precipitated; the aqueous particles intercepted between them muſt in that caſe have been decompoſed, and an immenſe quantity of inflammable air ſet looſe, the heat thus produced increaſing with the maſſes operated upon, muſt have riſen at laſt to incandeſcence; in that circumſtance the oxygen abſorbed muſt have been in great meaſure expelled, and in its naſcent ſtate meeting and uniting with the inflammable air muſt have burſt into flame. The progreſs of ſuch high degrees of heat muſt have diſengaged all the oxygen contained in the contiguous chaotic fluid, which uniting partly with more metallic iron, partly with the ſulphurated and partly with the carbonic and bituminous ſubſtances muſt have occaſioned

occaſioned a ſtupendous conflagration, the effects of which may well be ſuppoſed to have extended even to the ſolid baſis on which the chaotic fluid repoſed, and to have rent and ſplit it to an unknown extent.

That flame ſhould thus burſt from the boſom of the deep is not a forced ſuppoſition, but has frequently been verified in latter times. I ſhall only mention one inſtance which happened in the beginning of this century, when flames burſt out of the ſea near Tercera, and an iſland was elevated*.

These volcanic eruptions, many of which ſeem to have taken place at this period, chiefly in the ſouthern hemiſphere, were attended with important conſequences; the firſt muſt have been the diffuſion of a conſiderable heat through the whole maſs of the chaotic fluid, by which means the oxygen and mephitic airs diſperſed through it muſt have been extricated, and thus gradually formed the *atmoſphere*.

The ſecond was the production of fixed air from the union of oxygen with the ignited carbon; this at firſt roſe into and diffuſed itſelf through the atmoſphere, but in proportion as the chaotic fluid cooled it was gradually abſorbed by it. This abſorbtion occaſioned the precipitation, and more or leſs regular cryſtallization

* 6 Phil. Tranſ. Abridg. 2d Part, 203.

tallization of the *calcareous* earth, the greater part of which being much more ſoluble than the other earths, ſtill remained in ſolution after the others had for the moſt part been depoſited. This explains why many of theſe primitive calcareous maſſes are of all others the freeſt from foreign admixture. In ſome few inſtances however it muſt have happened that the calcareous particles intermixed with other earths were ſaturated before the reunion and depoſition of the other earths, and hence in ſome countries ſtrata of primitive calcareous maſſes occur in the midſt of gneiſs, or alternating with it; but theſe inſtances are very rare.

That the formation of fixed air was an event ſubſequent to the formation of moſt of the primæval ſtones, appears from the obſervation, that the calcareous earth found in the compoſition of primæval ſtones is in a cauſtic ſtate. 44 Roz. 206.

The immenſe maſſes concreted and depoſited on the interior nucleus of the earth formed the *primitive mountains*. It may perhaps be thought that this depoſition ſhould be equally diffuſed and ſhould conſtitute only an even cruſt over this interior nucleus, but ſuch a diſpoſition is contrary to the nature of cryſtallization, between whoſe ſhoots an interval always intercedes, if not too ſudden. The water firſt diſcharged of its diſſolved contents, and thereby heated, moved upwards, being preſſed by the circumambient denſer fluid, which was too heterogenous to mix with, and be diluted by it. The depoſit already formed affording to the ſucceeding portions of the charged fluid a baſis whoſe points of contact

contact were ſo much the more numerous as its height was greater, thereby determined theſe portions to a ſimilar depoſition, until the diminiſhed denſity or exhauſtion of the menſtruum diminiſhed or put an end to the number and extent of the points of contact of the depoſited maſſes with the ſolids contained in the menſtruum. In ſome caſes alſo, particularly after the chaotic fluid was heated by the cauſes already mentioned, and a conſiderable evaporation had enſued, the cryſtallization might have begun at the ſurface, as we ſee happen to ſome ſalts and to lime-water. Thus extenſive ſtrata might have been ſucceſſively depoſited, moſtly in an horizontal, but often from accidental ruptures during their fall, in an oblique or nearly vertical poſition. Thus far we are led by general analogies, without the aſſiſtance of romantic or gratuitous hypotheſes, and the view of the ſubject thus obtained is ſufficient for the explanation of moſt of the obſervations hitherto made on the ſtructure of primitive mountains.

The formation of *plains* is eaſily underſtood, in the wide intervals of diſtant mountains, after the firſt cryſtallized maſſes had been depoſited, the ſolid particles ſtill contained in the chaotic fluid, but too diſtant from each others ſphere of attraction to concrete into cryſtals, and particularly thoſe that are known to be leaſt diſpoſed to cryſtallize, and alſo to have leaſt affinity to water, were gradually and uniformly depoſited. Of this nature argillaceous particles are known to be, intermixed as may well be expected with a large proportion of ſiliceous and ferruginous particles

cles of all others the moſt abundant, and ſome particles of the other earths; by theſe compound and ſlightly concreted earths the ſurface of plains were originally covered. In proceſs of time theſe earths undoubtedly received an abundant increaſe from the decompoſition of primitive mountains, but this being an event of a poſterior date need here be only curſorily mentioned.

The next important event neceſſary to fit the globe for the reception of land animals was the diminution and receſs of the chaotic fluid in whoſe boſom the mountains were formed, and the conſequent diſcloſure of the dry land. This event was the natural conſequence of the operation of the preceding volcanos, by theſe the bed of the ocean was ſcooped, moſt probably as we ſhall hereafter ſee, in the *Southern* hemiſphere. But no change or tranſpoſition of the ſolid materials depoſited from the chaotic fluid could lower its level, unleſs the inferior *nucleus* of the globe could receive it within its hollow and empty caverns; this admittance it gained through the numerous rifts occaſioned by the antecedent fires; at firſt rapidly, but afterwards more ſlowly, in proportion as the perpendicular height of the fluid was diminiſhed, and thus the emerged continent conſiſting of mountains and plains was gradually laid bare and dried, and by drying, conſolidated.

The diſcloſure of the actual continents, as I have juſt hinted, appears to have been gradual. The tracts at firſt uncovered were

thoſe whoſe height over the preſent ſeas amounts to 8500 or 9000 feet, or more. This height comprehends moſt of the Eaſtern heights of Siberia, between latitude 49° and 55°, and of the extenſive regions of Great Tartary, Thibet, the deſert of Coby or Chamo, and China, reaching in ſome places to latitude 35°, and extending in the Northern parts from the ſources of the Irtiſh, long. 95°, and in the more Southern from the heads of the Ganges and Bourampooter, long. 80°, Hohanho and Porentſho to long. 190° at the leaſt, and perhaps ſtill farther into the unknown parts of Eaſtern America.

In Europe only the ſummits of the Alps, Pyrenees, and of a few other mountains were uncovered, but in America the narrow but long chain of the Cordeliers muſt have raiſed its ſummits far above the ocean; this fact is a neceſſary inference from that which I am next to mention.

The level of the antient ocean being lowered to the height of 8500 or 9000 feet, then and not before, it began to be peopled with *fiſh*. I ſhall therefore from its ſimilitude to our preſent *ſeas* henceforward denote it by this denomination, to diſtinguiſh it from the *chaotic fluid*, whoſe compoſition was ſo different and contained no fiſh.

That the creation of fiſh was an event ſubſequent to the emerſion of the tracts juſt mentioned and to the reduction of the

the waters to the height I have ſtated, is proved by the obſervations of all thoſe who have viſited thoſe countries. Pallas informs us that the immenſe deſert of Cobea or Chamo forms a flat platform whoſe elevation can be compared only to that of Quito in Peru (which Bouguer has ſhewn to amount to upwards of 9000 feet) and that the *plains* of the Monguls all along to the Chineſe wall are nearly of the ſame height *.

Major Rennel, in his account of the map of India, tells us that the country of Thibet is one of the higheſt in Aſia, being part of that elevated tract which gives riſe not only to the rivers of India and China, but to thoſe of Siberia and Tartary. The Southern ridge of the mountains of Boutan (Thibet) riſes, he ſays, about a mile and a half above the plains of Bengal, and may be ſeen in a horizontal diſtance of one hundred and fifty miles, p. 93 and 94, which indicates a height of fifteen thouſand feet, or allowing for refraction according to Dr. Maſkelyne's rule, eleven thouſand nine hundred and eighty-one feet.

According to Abbé Man's calculations, of all others the moſt accurate and the moſt moderate, the height of the Ganges and Hohanho, even at one thouſand miles diſtance from the ſea, muſt be three thouſand ſix hundred and thirty feet. But Major Rennel has ſhewn in the Philoſophical Tranſactions, 1781,

 p. 90,

* 1 Act. Petrop. 1777, p. 38.

p. 90, that the head of the Ganges is two thouſand miles diſtant from the ſea, therefore the country it flows from is elevated at leaſt eight thouſand eight hundred or nine thouſand feet.

Now in theſe elevated tracts no marine ſhells or petrifactions are found in the body of any mountain, nor in any ſtone not even in limeſtone though it abound particularly about the ſources of the Amour, Herm. 1 Chy. An. 1791, p. 155. But all the calcareous maſſes that occur are either what are called *ſaline* like Carrara marble, or ſo fine grained foliated as to appear nearly compact, but of the primitive kind. This abſence of marine ſhells and petrifactions from ſuch extenſive regions has attracted the particular notice of all travellers into theſe parts as they are ſo abundantly found in all lower tracts of the globe, Gmelin, 45. Phil. Tranſ. 254. Pallas, 1 Act. Petrop. 44. Patrin, 38 Roz. 227. And though ſalt ſprings and lakes are found in the higheſt plains, Pallas, ibid. 38, and even coal mines in the mountains, yet no organic remains accompany theſe mines as they do in the lower tracts of the globe, Patrin, 38 Roz. 226. Pallas indeed remarks ſome few petrifactions have been found in the rifts even of granitic mounts, but theſe he rightly judges were depoſited there at the time of the deluge; ibid. 44.

Hence I think it follows evidently that theſe tracts were indeed formed in the boſom of the primitive ocean, like all others, but

but that they were uncovered before the creation of fiſh, and ſince they contain limeſtone, that this ſtone does not neceſſarily and univerſally originate from comminuted ſhells, as Buffon and others have advanced.

That fiſh did not exiſt until the level of the ocean was depreſſed to eight thouſand five hundred feet may alſo be inferred with equal evidence from this obſervation, that tho' ſeveral lofty mountains at preſent exiſt which far exceed that height, yet no petrifactions or ſhells are incorporated in the rocks or ſtrata that form them. This De la Peyrouſe atteſts with reſpect to the Pyrenees, which yet are moſtly calcareous. *Traite des Mines de fer*, 336. Nor are any found in *Santo Velino*, the higheſt of the Appennines, its height being eight thouſand three hundred feet, whereas they abound in thoſe that are lower. In the Savoyan Alps Salenche, Saleve Mole, the Dole, all of which are calcareous, but below the height of ſeven thouſand feet, contain petrifactions, but the Buet, which is alſo calcareous for the greater part, but whoſe height exceeds ten thouſand feet, contains none. Sauſſure paſſim.

And reciprocally of the mountains that *contain* petrifactions imbodied in their maſs none reaches to the height of eight thouſand ſix hundred feet. With reſpect to the Hartz, Laſius remarks that no petrifactions are found in the mountains whoſe height exceeds two thouſand three hundred and ten feet,

feet, Laſius, 148; and Renovants, p. 76, aſſerts that none of thoſe of Siberia on each ſide of the Altai exceed two thouſand Paris feet. Nay Pallas does not allow to calcareous mountains that contain petrifactions (which on this account he judges to be formed in the ſea) above thirteen or fourteen hundred feet, 1 Act. Petrop. 59, but a view of the mountains of Switzerland ſhews that many of them are much higher.

The neareſt approach I have met with, to the limits I have aſſigned to the height of the antient ocean when it began to be peopled with fiſh, is an obſervation of Mr. De Luc's, that he found cornua ammonis petrified on mount Grenier, whoſe height is ſeven thouſand eight hundred feet, 2d Lettres a la Reine, 227; and another of Baron Zoits on the mountain of Terglore in Carniola, that petrifactions were found in limeſtone at the height of between thirteen and fourteen hundred German lachters, taking ſuch to be equal to thoſe of the Hartz, the height was eight thouſand five hundred Engliſh feet nearly, and hence I have extended the limits to eight thouſand five hundred feet, yet it does not appear by Mr. De Luc's relation that theſe petrifactions were imbodied in the ſtone or rock which conſtitutes the mountain, and therefore may well be only relics of the deluge. He alſo ſays that the chain of Jura abounds in marine remains, but Jura conſiſts of two chains, the higheſt of which conſiſts of primæval limeſtone in which no petrifactions are found, and this is the higheſt, 30 Roz. 275, but the lower

lower chain certainly abounds in them. Fichtel alſo remarks that ſtill higher on the mountains of Terglore no petrifactions are found imbodied, Mineral Aufsatz, p. 4.

After this elevated tract of the globe had been uncovered, there is no reaſon to ſuppoſe that it long remained diveſted of vegetables or unpeopled by animals, being in every reſpect fitted to receive them. The ſevere degree of cold which at preſent diſtreſſes theſe countries during the winter months is ſolely owing to their diſtance from and elevation over the actual ſeas (as I have elſewhere ſhewn), circumſtances that did not exiſt at this period.

That the retreat of the ſea from the lower parts of our preſent continents was gradual and not fully effected until after the lapſe of ſeveral centuries many reaſons induce us to believe. 1°. Both ſides of the Altaiſchan platform exhibit ſecondary mountains (ſo I call all thoſe which contain marine ſhells or other remains of animal or vegetable ſubſtances between their ſtrata, or incorporated in the rocks or ſtones of which they conſiſt) both of the calcareous and argillitic kind, in which marine ſhells abound, Renov. 75, theſe therefore muſt have been formed before the ſea had receded far from theſe parts, and muſt have been the work of many years.

2do. Not only in every region of Europe but alſo of both the old and new continents, whoſe ſituation is inferior to that above-mentioned,

mentioned, immenſe quantities of marine ſhells either diſperſed or collected have been diſcovered. In the province of Touraine in France, at one hundred miles diſtance from the ſea, there exiſts at a depth of eight or nine feet a heap of ſhells of nine leagues in ſurface and upwards of twenty feet in depth, many of which are thoſe of the neighbouring ſeas, a collection which certainly required many years to accumulate.—Mem. Paris, 1720. p. 524, 540. Moſt of theſe ſhells are placed on their flat and not on their convex ſurface.—Ibid. which ſhews they muſt have been gently depoſited, and not huddled together by a ſudden and violent inundation. In ſome places ſhells of different ſpecies are thus accumulated, but in others they are regularly arranged in families.—1 Bergm. Erdekug. 251, 262. 6 Roz. 120. Widem. Verwandl. 118. which ſhews alſo that they were neither ſuddenly nor promiſcuouſly collected. Many ſmaller but ſimilar accumulations occur in England, as may be ſeen in the Philoſ. Tranſ. and Ray's Diſcoveries, and in Peru 2 Don. Ulloa's Voy. 197. and alſo in Italy, Spain, Germany, Poland, Sweden, &c. which being generally known and acknowledged it is needleſs to detail, but it deſerves particular attention, though many of them are found at a depth of from eight to one or two hundred feet under the ſurface of the earth, and at ſtill greater depths from the ſurface of mountains, yet ſcarce any are found lower than the actual ſurface of the bed of the ſea.—1 Bergm. Erde, 176. Some indeed are found that do not now occur in the neighbouring coaſt, becauſe they are of the kind called *Pelagicæ*, which exiſt only at great depths,

depths, as Don Ulloa has ſhewn, 2 Voy. 197. or becauſe the temperature of the actual ſeas is unfit for them, as the ancient ſeas, from the ſmaller extent of the ancient continents, muſt have been much warmer, nay the number of theſe unknown ſhells is daily diminiſhing.

We may alſo remark that the loweſt countries, as Brabant and Holland, contain moſt of them. In particular tracts of Ruſſia they are alſo very copious, becauſe theſe tracts were longer covered by the ſea than moſt other countries, as will be ſhewn in a future Eſſay.

4°. Trees of different kinds and various vegetables have been found in great depths in our modern continents, and even under lofty mountains, as at Meiſſen in Heſſia, and often mixed with marine remains. Some parts of the earth on which theſe trees grew muſt therefore have been dry land, while thoſe parts in which the trees are found were covered by the ſea, therefore the retreat of the ſea muſt have been gradual. Many I am ſenſible aſcribe theſe depoſitions to the ravages of the univerſal deluge, and in ſome caſes I believe juſtly, but as they are often under hills or mountains, whoſe ſtrata are regularly diſpoſed, a regularity that can ſcarce be ſuppoſed to take place during the turbulence of a deluge, in theſe caſes it appears their depoſition muſt be aſcribed to more tranquil cauſes.

5°. Trees have often been found depoſited near the ſummits of many mountains at heights in which from the degree of cold which at preſent prevails on them they could not grow, therefore they muſt have grown when the temperature of theſe ſummits was warmer, and conſequently when they were leſs elevated over the ſurface of the ſea, and leſs diſtant from it.

Lastly,—Stratified mountains of various heights beneath eight thouſand feet exiſt in different parts of Europe, and of both continents, in and betwixt whoſe ſtrata various ſubſtances of marine, and ſome vegetables of terreſtrial origin repoſe, either in their natural ſtate or petrified; the regularity and uniformity of theſe ſtrata ſtrongly indicate a cauſe whoſe action was regular and uniform and long continued; now tides are the only cauſe of this nature with which we are acquainted; ſudden and violent inundations and of ſhort continuance are incompatible with ſtratifications ſo regular and numerous. In ſome few inſtances, it is true, much irregularity and confuſion prevails amongſt the ſtrata, from the diſſolution, elapſion, or different compreſſion of ſome of theſe ſtrata, or from their interruption during their formation, by the introduction of extraneous rocks projected amongſt them by adventitious cauſes, as earthquakes or volcanos; or the tides themſelves may have ſometimes been rendered irregular by ſtorms, currents or the irregular profile of the ſhores, as we daily obſerve. But even in theſe caſes the length of time neceſſary for the formation of the ſtrata exclude all ſuſpicion of ſhort and tumultuary inundations.

We

We alſo obſerve, that though the ſtrata themſelves are not arranged in the order of the ſpecific gravities of the materials that compoſe them, the lighter being frequently placed beneath the heavier, yet within each ſtratum the materials that compoſe it are almoſt always arranged according to the laws of their gravitation. 1 Bergm. Erde, 179.

These phænomena fully prove that the retreat of the ſea from the vicinity of the lofty mountains and elevated platforms that firſt emerged was not ſudden, but continued for ſeveral ages, and that the various ſtratified ſecondary mountains at preſent exiſting were formed within it during its retreat, and after the creation of fiſh. The mode of their formation now claims our attention.

To form as juſt an idea of the formation of ſecondary mountains as the nature of an object inſcrutable to human eyes can allow us, we muſt obſerve, 1°. That the greater part of the particles of ſolid matter contained in the chaotic fluid being depoſited before the creation of fiſh, the various materials that enter into the compoſition of ſecondary mountains muſt have been furniſhed either by the deſtruction of ſuch of the primary as exiſted in the ſea, but either from want of ſolidity or the ſmallneſs of their maſs were too feeble to reſiſt its impetuoſity when animated by ſtorms, and being by continued friction reduced to atoms or rolled into tumblers were either diffuſed through or hurried along by the

agitation of the waters, or were crumbled to pieces by earthquakes, and variouſly diſperſed through the ocean, or theſe materials were ejected in immenſe heated maſſes, by ſubmarine volcanos into the boſom of the waves, to be by them farther comminuted, diſintegrated or decompoſed.

The various ſolids thus diffuſed at different periods of time through the vaſt body of the ocean muſt have been gradually precipitated and depoſited on ſuch ſolid maſſes as reſiſted the progreſſive motion impreſſed upon the precipitating maſſes by that tumultuous element; hence they applied to and reſted on the low lateral ſurfaces of many of the moſt conſiderable primary mountains, or were accumulated on the ſcabrous but firmly rooted fragments of ſuch of thoſe mountains as were before deſtroyed, intombing the ſhell-fiſh that adhered to or reſted upon theſe fragments, and arreſting by their initial ſoftneſs the various ſunk woods and other vegetable or animal ſubſtances as chanced to be mixed with theſe precipitating maſſes, or were ſubſequently borne upon them. Trees naturally aſſumed the ſituation that afforded leaſt reſiſtance to the currents that conveyed them, and hence the uniformity that has been obſerved very frequently in their poſition. Theſe depoſitions, when during their deſcent they attained a certain degree of denſity, muſt have proved fatal to the various ſpecies of fiſh which were involved in them, and hence the origin of the more ſolid piſcine remains at preſent found in them; the ſofter parts being deſtroyed by putrifaction, in this manner,

manner, but after long intervals of time, the ſucceeding ſtrata appear to have been formed, but they did not attain their preſent ſolidity until after the retreat of the ſea, and through the operation of cauſes which I ſhall preſently mention.

From the circumſtances here ſtated we may eaſily account for ſeveral of the moſt general geological obſervations, as,

1°. Why ſtratified hills have always been found repoſing on primary rocks or inveſting primary mountains, as on granite, gneiſs, argillite, &c. as Ferber, Born, Pallas, Gerhard, Charpentier, Werner, Sauſſure, &c. atteſt, not as matters of opinion, but as facts they have conſtantly been witneſſes to. Doctor Hutton indeed thinks this obſervation does not hold true with reſpect to Scotland, or even with reſpect to the greater part of Britain, becauſe in traverſing the greater part of that iſland he ſeldom met with granite; but it is plain from what has been ſaid, that it is not on the ſurface it ſhould be expected, but under the ſuperior ſtrata, therefore the Doctor's obſervations, but not his aſſertions, are perfectly conſiſtent with thoſe of all other geologiſts. However Mr. Everſman of Berlin, who reſided ſome years in Scotland, tells us that the fundamental rock (*Grund gebirge*) of Scotland is a maſs of the *granitic kind*, 1 Bergm. Jour. 1789, 495, and Doctor Aſh relates that not only near Aberdeen, but in the more ſouthern parts, extenſive granitic mountains often occur, 1 Chy. Ann. 1792, 115. The truth is that the whole of Britain ſeems to have been formed

formed of ſtrata, reſting upon and intercepted between maſſes of granite or other primitive rocks, at depths in moſt places not eaſily acceſſible.

2do. Why the ſtrata of ſecondary mountains are generally elevated in the direction that faces the next primitive mountains, though frequently diſtant from them, being as we have ſeen originally formed againſt, and along the ſloping ſides of thoſe mountains, and the ſeparation occaſioned by the courſe of waters that formed the vallies that intercede between them. The ſeeming exceptions to this rule ariſe either from the ſinking of the primitive mountain to which the ſecondary faced, as happened to that which ſtood where the lake of Geneva is now placed, whoſe bottom is chiefly granite, or ſome other primitive rock, as Mr. Sauſſure atteſts, 1 Sauſſ. 15, and therefore the elevation of the ſtrata of the Mole, Saleve, &c. face the lake, Id. p. 222, 223, &c. or becauſe theſe ſtratified hills were originally independent, being formed on the fragments of primitive mountains, as already ſaid.

Hence alſo we may explain an important obſervation made by Mr. Schreiber on the mountain of Gardette, which conſiſts of limeſtone ſuperimpoſed on gneiſs; he obſerved that where they joined, the gneiſs had penetrated into the body of the limeſtone, but the limeſtone did not penetrate into that of the gneiſs, whence he

he juſtly inferred that the limeſtone was in a ſoft ſtate, but the gneiſs already conſolidated, when the contact took place; 36 Roz. 359. Similar to this is the obſervation of Mr. Sauſſure, 1 Sauſſur. 528, that a puddingſtone with a calcareous cement or argillaceous grit is generally interpoſed betwixt the uppermoſt ſtrata of the primary and the loweſt of the ſecondary ſtrata as the ſoft ſecondary matter inveloped the *pebbles* or *gravel* on the ſurface of the primary; this he obſerved in the Alps, the Voſges, the Cevennes, &c. This is alſo conſtantly obſerved in coal mines where ſemi-primigenous ſtrata (Todliegendes) a ſandſtone or brecia with a calcareous or argillaceous cement, forms the laſt ſtratum immediately over the primitive rock.

MANY, indeed moſt of the obſervations hitherto made, are explicable on theſe principles, which, not to extend this part of the Eſſay beyond its due limits, I here omit.

THE retreat of the ſea appears to have continued through the rifts already mentioned, or poſſibly through others ſubſequently made, probably until a few centuries before the deluge. Its ceſſation long before the deluge I infer from the hardneſs which the mountains muſt have acquired to withſtand the ſhocks they muſt have underwent during that cataſtrophe. To acquire this hardneſs a long period of time was neceſſary, both for their deſiccation and the infiltration of thoſe particles to which the ſtrata of ſecondary mountains owe their ſolidity.

I DO

I DO not by this pretend that the ſecondary ſtrata had not acquired a certain degree of ſolidity in a few minutes, even after their depoſition, and conſequently long before their emerſion; on the contrary this muſt ſoon have been acquired in the ſame manner as we find calcareous depoſits to harden at the bottom of ſalt-pans and tea-kettles, while full of liquor, and tartar in hogſheads of wine, and pouzzolana mortar, &c. but this hardneſs is moderate in compariſon of that which they acquired by deſiccation and continued infiltration, as we daily experience in moiſt limeſtone quarries, where though the ſtone is originally hard, yet it becomes much harder when dried. The induration effected by infiltration is ſtill more conſiderable, as by it the minuter particles of bodies are conveyed into the minuteſt interſtices. Hence we ſee that traps and baſaltic pillars are always harder at the bottom than at the top, Cronſt. § 267, and the upper ſtrata of limeſtone, particularly of that ſpecies called freeſtone, are always ſofter near the ſurface of the quarry than at a greater depth; that ſuch infiltration is not an imaginary proceſs, let it be explained how it may, and conſequently that the hardneſs of the lower ſtrata does not proceed merely from the preſſure of the upper, appears by an elegant obſervation of Mr. Werner's, that where various ſtrata of a different nature occur, the petrifactions that are found in the inferior, are frequently filled with the matter of the ſuperior inſtead of that of the ſtratum which contains them, Wedem. Verwandl. 118. The petrified ſhells found in clay or argillites are commonly compreſſed and flatted, as Mr. Bergman remarks, as

argil

argil hardens by contraction, but thoſe found in limeſtone retain their primitive ſhape, as theſe harden chiefly by infiltration.

I NOW proceed to the Moſaic account of theſe events, " In " the beginning God created the heaven and the earth," that is to ſay, the firſt event in the hiſtory of this globe was its creation, and that of all the planets then known.

" AND the earth was without form and void," that is to ſay, that the earth at the time of its creation was without form, &c. therefore another terraqueous globe did not previouſly exiſt in a *complete ſtate* out of the ruins of which the preſent earth was formed, as ſome have lately imagined; *without form and void* the Hebrew has *Tohu* and *Bohu*. Ainſworth remarks that *Tohu* ſignifies a ſtate of confuſion, and *Bohu* a ſtate of vacuity; ſee Pool's Synopſis. That is to ſay, that the earth was partly in a *chaotic* ſtate, and partly full of *empty* cavities, which is exactly the ſtate, which from the conſideration of the ſubſequent phenomena, I have ſhewn to have been neceſſarily its primordial ſtate.

" AND darkneſs was on the face of the deep," conſequently light did not at firſt exiſt. The *deep*, or abyſs, properly denotes an immenſe depth of water, but here it ſignifies, as Mede and Eſtius obſerve, the mixed or chaotic maſs of earth and water.—David, whoſe knowledge was derived from Moſes, and who probably poſ-

ſeſſed a leſs abridged copy of Geneſis than we do, expreſsly tells us that the earth was covered with water;" the abyſs, like a garment, " was its covering." Pſalm civ. v. 6.

HENCE we ſee that the water was from the beginning in a liquid ſtate (and not in that of ice) as I have mentioned: and conſequently elementary fire, or the principle of heat, exiſted from the beginning.

" AND the ſpirit of God (or rather *a* ſpirit of God) moved on the " face of the waters;" here *ſpirit* denotes an inviſible elaſtic fluid, viz. the great *evaporation* that took place ſoon after the creation, as ſoon as the ſolids began to cryſtallize, as I have ſhewn. *Of God*, is a well known Hebrew idiom denoting *great; moved*, or rather *hovered*, over the waters. David here mentions a fact which he undoubtedly took from Moſes, though omitted in our preſent copies of Geneſis, and this fact is eſſential to our theory, namely, that " the waters ſtood *above the mountains.*" Pſalm civ. v. 6. Therefore the mountains were formed in the boſom of the waters, as I have ſtated. Nay he uſes an expreſſion that moſt probably hath hitherto been ill underſtood, that " God fixed the earth on its baſis, from " which it ſhall not be removed for ever." This appears to me to denote the depoſition of the ſolids contained in the chaotic waters, on the ſolid kernel of the globe, from whence they ſhould never be removed nor indeed have they ever ſince.

" And

" And God ſaid let there be light, and there was light;" here we may obſerve that *facts* only, were revealed to Moſes or the perſon (moſt probably Adam) from whom their tradition deſcended. The words choſen by Moſes, or this perſon, were ſuch as coincided with his own notions, or were moſt intelligible to an ignorant people. The phraſes, *God ſaid*, *God ſaw it was good*, *God called*, uſed in this chapter, are mere anthropological phraſes, ſuited to the conception of thoſe to whom theſe facts were related, for religious and moral and not merely for ſcientific purpoſes. To men of ſcience their ſignification could not be ambiguous. " *God ſaid*," ſignifying no more than that events naturally poſſible took place by virtue of the laws of their production, which laws God had eſtabliſhed. " *God ſaw it was good*," ſignifies merely that it was good, and the expreſſion " *God called*," denotes no more than that it received ſuch a name.

The production of light ſtands next in the order of events recorded by Moſes, as it does in our theory, and moſt probably denotes the *flames* of volcanic eruptions, the Hebrew certainly bears this ſignification. The period of its exiſtence Moſes called *day*, evidently from its reſemblance to *true* days, which could have exiſted only at a ſubſequent period, namely after the ſun had gained its luminous powers.

" And God ſaid, let there be a firmament in the midſt of the " waters, and let it divide the waters from the waters." Here Moſes

indicates the production of the atmoſphere, the word which in our tranſlation is rendered *firmament* * moſt properly ſignifies *expanſe*, or an expanded or dilated ſubſtance; than which a more proper name could not ſurely be choſen for the atmoſphere. "To divide "the waters from the waters;" that is, to ſeparate and contain vapours, which is one principal uſe of the atmoſphere.

"And God ſaid, let the waters under the heavens be gathered "together in one place, and let the dry land appear, and it was "ſo." This is the fifth event which Moſes places in the ſame order of ſucceſſion that mere philoſophical conſiderations aſſign to it.

The word *appear* is remarkable, as it ſeems to denote that the diſcloſure of the earth was *ſucceſſive*, and had not from the beginning fully and compleatly taken place.

The events immediately ſubſequent I omit, as not relating to geology, and ſhall only mention the creation of fiſh, a fact of great importance in the theory of the earth; this Moſes, as well as philoſophy, tells us happened after the ſeparation of the waters from the dry land and primitive mountains. He alſo relates that the creation of land-animals was ſubſequent to that of fiſh; a fact which

* Some interpreters think *firmament* implies ſomething ſolid, becauſe the general opinion of the Heathen oriental ſages was, that the heavens were ſolid, as if the *true ſenſe* of the Hebrew was to be derived from *falſe opinions* deviſed many ages after Moſes.

which geological obſervations alſo indicate, for their remains are always found near the ſurface of the earth, whereas thoſe of fiſh are found at the greateſt depths. This order of ſucceſſion is not only allowed by Mr. Buffon, but made one of the principal pillars of his ſyſtem. 1 Epoque's de la Nature, p. 231 in 8vo.

HERE then we have ſeven or eight geological facts, related by Moſes on the one part, and on the other, deduced ſolely from the moſt exact and beſt verified geological obſervations, and yet agreeing perfectly with each other, not only in *ſubſtance* but in the order of their ſucceſſion. On whichever of theſe we beſtow our confidence, its agreement with the other demonſtrates the truth of that other. But if we beſtow our confidence on *neither*, then their *agreement* muſt be accounted for. If we attempt this, we ſhall find the *improbability* that both accounts are falſe, infinite; conſequently one muſt be true, and, then, ſo muſt alſo the other.

THAT two accounts derived from ſources totally diſtinct from and independent on each other ſhould agree not only in the ſubſtance but in the order of ſucceſſion of two events only, is already highly improbable, if theſe facts be not true, both ſubſtantially and as to the order of their ſucceſſion. Let this improbability, as to the ſubſtance of the facts, be repreſented only by $\frac{1}{10}$. then the improbability of their agreement as to ſeven events is $\frac{1^{\cdot 7}}{10^{\cdot 7}}$, that is, as one to ten million, and would be much higher if the *order* alſo had entered into the computation.

SECOND

SECOND ESSAY

ON THE

DELUGE.

HAVING, I flatter myſelf, eſtabliſhed, in the preceding Eſſay, the credit due to Moſes on mere philoſophic grounds, and abſtracting from all theological conſiderations, I ſhall not ſcruple taking him as a guide as far as his teſtimony reaches, in tracing the circumſtances of the moſt horrible cataſtrophe to which the human and all animal ſpecies, and even the terraqueous globe itſelf, had at any period ſince its origin been expoſed. His teſtimony is indeed in ſubſtance confirmed by the traditions of many antient nations, which may be ſeen in Grotius de Veritate Huet Queſt. Alnet. lib. ii. chap. xii. Euſeb. Prep. Evang. Lib. ix. &c. and therefore needleſs to adduce; it is more to our purpoſe to prove it by geological facts, of which there are ſome that ſeem to me perfectly concluſive.

1ſt, According to Don Ulloa, ſhells were found on a mountain in Peru at the height of 14220 feet, 2 Buff. Epoque, 268. Now I have already ſhewn, in the former Eſſay, that no mountains higher than 8500 feet were formed ſince the creation of

of fiſh, or, in other words, that fiſh did not exiſt until the original ocean had ſubſided to the height of eight thouſand five hundred feet above its preſent level. Therefore the ſhells found at more elevated ſtations were left there by a ſubſequent inundation. Now an inundation that reached ſuch heights could not be partial, but muſt have extended over the whole globe.

2dly, The bones of elephants and of rhinoceri, and even the intire carcaſe of a rhinocerus, have been found in the lower parts of Siberia. As theſe animals could not live in ſo cold a country they muſt have been brought thither by an inundation from warmer and very diſtant climates, betwixt which and Siberia mountains above nine thouſand feet high intervene. It may be replied that Siberia, as we have already ſhewn, was not originally as cold as it is at preſent; which is true, for probably its original heat was the ſame as that of many iſlands in the ſame latitude at this day, but ſtill it was too cold for elephants and rhinoceri, and between the climates which they might have then inhabited and the places they are now found in too many mountains intercede to ſuppoſe them brought thither by any other means but a *general* inundation. Beſides, Siberia muſt have attained its preſent temperature *at the time* theſe animals were tranſported, elſe they muſt have all long ago putrified.

3dly, Shells known to belong to ſhores under climates very diſtant from each other are in ſundry places found mixed promiſcuouſly

cuouſly with each other; *one ſort* of them, therefore, muſt have been tranſported by an inundation; the promiſcuous mixture can be accounted for on no other ſuppoſition.

These appear to me the moſt unequivocal geologic proofs of a general deluge. To other facts generally adduced to prove it, another origin may be aſcribed; thus the bones of elephants found in Italy, France, Germany, and England, might be the remains of ſome brought to Italy by Pyrrhus or the Carthaginians, or of thoſe employed by the Romans themſelves; ſome are ſaid to have been brought to England by Claudius. 4 Phil Tranſ. Abr. 2d part, 242. When theſe bones, however, are accompanied with marine remains, their origin is no longer ambiguous. Thus alſo the bones and teeth of whales, found near Maeſtricht, are not deciſively of diluvian origin, as whales have often been brought down as low as Lat. 48°. 34 Roz. 201. Nay ſometimes they ſtrike on the coaſt of Italy. 1 Targioni Tozzetti 386.

Yet, to explain the leaſt ambiguous of theſe phœnomena, without having recourſe to an univerſal deluge, various hypotheſes have been framed.

Some have imagined that the axis of the earth was originally parallel to that of the ecliptic, which would produce a perpetual ſpring in every latitude, and conſequently that elephants might exiſt in all of them. But the ableſt aſtronomers having demonſtrated

ſtrated the impoſſibility of this parallelism, it is unneceſſary to examine its conſequences; it only deſerves notice that the obliquity of the equator is rather diminiſhing than increaſing. See La Lande in 44 Roz. 212. Beſides, why are theſe bones accompanied by marine remains? Others, from this nutation of the earth's axis, have ſuppoſed that its poles are continually ſhifting, and conſequently that they might have originally been where the equator now is, and the equator where the poles now are; thus Siberia might have, in its turn, been under the equator. But as the nutation of the earth's axis is retrogreſſive every nine years, and never exceeds ten degrees, this hypotheſis is equally rejected by aſtronomers. 44 Roz. 210. 2 Bergm. Erde Kugel 305. The pyramids of Egypt demonſtrate that the poles have remained unaltered theſe three thouſand years.

The 3d hypotheſis is that of Mr. Buffon, to which the unfortunate Bailly has done the honour of acceding; according to him the earth, having been originally in a ſtate of fuſion, and for many years red hot, at laſt cooled down to the degree that rendered it habitable. This hypotheſis he was led to imagine from the neceſſity of admitting that the globe was, at leaſt to a certain diſtance beneath its ſurface, originally in a ſoft ſtate; the ſolution of its ſolid parts in water he thought impoſſible, falſely imagining that the whole globe muſt have been in a ſtate of ſolution, whereas the figure of the earth requires the liquidity of it only a few miles beneath its ſurface. Epoques, 10. and 35. If he had trod the

path of experiments he would have found both the hardneſs and tranſparency, of what he calls his primitive glaſs, and thinks the primitive ſubſtance of the globe, namely *quartz*, to be altered in a ſtrong heat with a loſs of 3 per cent. of its weight, and that ſo far from having been a glaſs, that it is abſolutely infuſible. The loſs of weight, he muſt have ſeen, could be aſcribed to nothing elſe but the loſs of its watery particles, and that therefore it muſt have been originally formed in water; he would have found that ſome *felſpars* loſe 40 per cent. and others at leaſt 2 per cent. by heat; he would have perceived that *mica*, which he thinks only an exfoliation of quartz, to be in its compoſition eſſentially different. He certainly found their cryſtallization inexplicable, for he does not even attempt to explain it.

But waving this, and a multitude of other inſuperable difficulties in his hypotheſis, and adverting only to the ſolution he thinks his theory affords, of the phœnomenon of the exiſtence of the bones of elephants, and the carcaſe of a rhinoceros in Siberia, I ſay it is defective even in that reſpect. For allowing his ſuppoſition that Siberia was at any time of a temperature ſo ſuited to the conſtitution of theſe animals that they might live in it, yet the remains lately found in that country cannot be ſuppoſed to belong to animals that ever lived in it:

1ſt, Becauſe though they are found at the diſtance of ſeveral hundred miles from the ſea, yet they are ſurrounded by genuine marine vegetables, which ſhews that they were brought thither together with thoſe vegetables.

2dly,

2dly, Becauſe they are generally found in accumulated heaps, and it is not to be imagined that while alive they ſought a common burial place no more than they at preſent do in India.

3dly, Becauſe the rhinoceros was found intire and unputrified, whereas if the country was warm when he periſhed this could not have happened.

4thly, Becauſe in no very diſtant latitude *, namely that of Greenland, the bones of whales, and not of elephants, are found on the mountains, conſequently that latitude muſt have been in that ancient period ſufficiently cold to maintain whales, as it is at this day; and that cold we know to be very conſiderable, and incompatible with the proximity of a climate ſuited to elephants. 17 N. Comment. Petropol. 576. 1 Act. Petrop. 55. Renov. 73. Therefore the animals whoſe remains are now found in Siberia could not have lived in it.

The 4th hypotheſis is that of Mr. Edward King, but much amplified and enlarged by Mr. De Luc. This juſtly celebrated philoſopher is of opinion that the actual continents were, before the deluge, the bottom or bed of the ancient ocean, and that the deluge conſiſted in the ſubmerſion of the ancient continents, which conſequently form the bottom or bed of our actual oceans, con-

 ſequently

* The bones were found in latitude 55°.

ſequently our actual mountains were all formed in the antediluvian ocean, and thus ſhells might be left on their higheſt ſummits.

In this hypotheſis the ancient continents muſt have exiſted in thoſe tracts now covered by the Atlantic and Pacific Oceans; if ſo, I do not ſee how the elephants could have been brought into Siberia, or a whole rhinoceros found in it: For Siberia being then the bottom of ſome ocean, the ſea muſt have moved *from it* to cover the ſinking continents, inſtead of moving *towards it*, to ſtrew over it their ſpoils.—If it be ſaid that theſe animals were carried into the ſea before the flood, then, aſſuredly, the rhinoceros ſhould have been devoured, and only his bones left.

To ſay nothing of the incompatibility of this ſyſtem with the principal geologic phœnomena mentioned in my former Eſſay, and of the deſtruction of at leaſt all the graminivorous fiſh that muſt have followed from their transfer to a ſoil not ſuited to them, it is evidently inconſiſtent with the Moſaic account of this cataſtrophe, which account theſe philoſophers however admit.

Moses aſcribes the deluge to two principal cauſes, a continual rain for forty days, and the eruption of the waters of the great abyſs. Now to what purpoſe a rain of forty days to overwhelm a continent that was to be immerſed under a whole ocean? He tells us the waters *increaſed* on the continents a certain number of days, *reſted* thereon another period of days, and then *returned*.

Do

Do not theſe expreſſions imply a permanent *ground* on which they increaſed and reſted, and from which they afterwards retreated? As the retreat followed the advance, is it not clear that they retreated from the *ſame* ſpaces on which they had before advanced and reſted?

Mr. De Luc replies, that in the 13th verſe of the 6th chapter of Geneſis, it is ſaid the earth ſhould be *deſtroyed*, and that Mr. Michaelis ſo tranſlates it. However it is plain, from what has been juſt mentioned, that Moſes did not underſtand ſuch a deſtruction as ſhould cauſe it to diſappear totally and for ever; he tells us that the waters ſtood 15 cubits over the higheſt mountains; now as he has no where mentioned the antediluvian mountains, but has the poſtdiluvian, it is plain that it is to theſe his narration relates, and theſe he tells us were at the time of the deluge covered with water, and uncovered when the waters diminiſhed; he never diſtinguiſhed the poſtdiluvian from the antediluvian, and therefore muſt have conſidered them as the ſame.

Nor did Noah himſelf believe the ancient continents deſtroyed, for he took the appearance of an olive branch to be a ſign of the diminution of the flood. This he certainly believed to have grown on the ancient continent, and could not expect it to have ſhot up from the bottom of the ſea.—Mr. De Luc tells us that this olive grew on an antediluvian iſland, and that theſe iſlands, being part of the antediluvian ocean, were not flooded—it is plain, however, Noah did not

not think ſo, elſe he would not judge the appearance of the olive to be a ſign of the diminution of the waters.—Where is it mentioned or what renders it neceſſary to infer that iſlands exiſted before the flood? If iſlands did exiſt, and were to eſcape the flood, ſo might their inhabitants alſo, contrary to the expreſs words of the text.

It would ſurely be much more convenient for Noah, his family and animals, to have taken refuge in one of them, than to remain pent up in the ark.

The dove, Moſes tells us, returned the firſt time ſhe was let out of the ark, *finding no place whereon to reſt her foot*; ſhe conſequently could not diſcover the iſland, whereas the raven never returned, plainly becauſe he found carcaſſes whereon to feed, therefore theſe carcaſſes were not ſwallowed up, as Mr. De Luc would have it. Moſes tells us that at the ceſſation of the flood the fountains of the deep were ſtopped or ſhut up; therefore, in his apprehenſion, inſtead of the ancient continents ſinking into the deep, the waters of the abyſs flowed from their ſources upon that continent, and again returned; from all which it follows that this hypotheſis is as indefenſible as the foregoing.

Paſſing over the ſyſtems of Burnet, Woodward and Whiſton, which have been repeatedly refuted, I recur to the account of this great revolution given by Moſes himſelf, taken in its plain literal ſenſe,

ſenſe, as the only one that appears perfectly conſiſtent, with all the phœnomena now known, of which I ſhall find occaſion to mention many; he plainly aſcribes it to a ſupernatural cauſe, namely the expreſs intention of God to puniſh mankind for their crimes. We muſt therefore conſider the deluge as a miraculous effuſion of water, both from the clouds and from the great abyſs; if the waters, ſituated partly within and partly without the caverns of the globe, were *once* ſufficient to cover even the higheſt mountains, as I have ſhewn in the former Eſſay, they muſt have been ſufficient to do ſo a ſecond time when miraculouſly educed out of thoſe caverns.

Early geologiſts, not attending to theſe facts, thought all the waters of the ocean inſufficient; it was ſuppoſed that its mean depth did not exceed a quarter of a mile, and that only half of the ſurface of the globe was covered by it; on theſe *data* Keil computed that twenty-eight oceans would be requiſite to cover the whole earth to the height of four miles, which he judged to be that of the higheſt mountains, a quantity at that time conſidered as extravagant and incredible, but a further progreſs in mathematical and phyſical knowledge has ſince ſhewn the different ſeas and oceans to contain at leaſt forty-eight times more water than they were ſuppoſed to do.

Mr. De La Place, calculating their average depth, not from a few vague and partial ſoundings, for ſuch they have ever been, (the

(the polar regions having been never ſounded, particularly the Antartic) but from a ſtrict application of the theory of tides to the height to which they are known to riſe in the main ocean, demonſtrates that a depth, reaching only to half a league, or even two or three leagues, is incompatible with the Newtonian theory, as no depth under four leagues could reconcile it with the phœnomena *—The vindication of the Moſaic hiſtory does not require near ſo much. The extent of the ſea is known to be far greater than Keil ſuppoſed, that of the earth ſcarcely paſſing $\frac{1}{3}$ of the ſurface of the globe.

The poſſibility and reality of the deluge being thus eſtabliſhed, I ſhall next endeavour to trace its origin, progreſs, and ſtill permanent conſequences. That it originated in and proceeded from the great ſouthern ocean below the equator, and thence ruſhed on the northern hemiſphere, I take to be a natural inference from the following facts :

1ſt, The ſouthern ocean is the greateſt collection of waters on the face of the globe.

2d, In the northern latitudes beyond 45° and 55° we find the animal ſpoils of the ſouthern countries, and the marine exuviæ of the ſouthern ſeas, but in the ſouthern latitudes we find no remains

* Mem. Paris, 1776.

remains of animals, vegetables or ſhells belonging to the northern ſeas, but thoſe only that belong to the neighbouring ſeas. Thus in Siberia, to return to the already frequently mentioned phœnomenon, we find the remains of elephants and rhinoceri accompanied by marine vegetables, and alſo with ſhells that do not belong to the northern ocean. 1 Epoques 418. They muſt therefore have been conveyed thither by the more diſtant Indian ſea overflowing theſe parts; as the elephants very naturally crowded together on the approach of the inundation, they were conveyed in flocks, and hence their bones are found in accumulated heaps, as ſhould be expected *. But in Greenland, which is ſtill more diſtant, only the remains of whales are found on the mountains. Crantz Hiſtoire Generale des Voy. vol. xix. 105. So in the ſouthern latitudes, as at Talcaguana in Chili, latitude 36° S. the ſhells found on the tops of the hills are thoſe of the neighbouring ſea. 2 Ulloa Voy. p. 197. So thoſe found on the hills between Suez and Cairo are the ſame as thoſe now found in the Red Sea. Shaw's Voyages, vol. ii.

3dly, The traces of a violent ſhock or impreſſion from the ſouth are as yet perceptible in many countries. This Mr. Patrin atteſts as to the mountains of Dauria on the ſouth eaſt limits of Siberia; he tells us that the more eaſtern extremities of the mountains appear to be broken off by the impetuoſity of an ancient ocean

* The elephantine remains found in Ruſſia were conveyed thither from Perſia.

ruſhing from caſt to weſt, that the fragments carried to the weſt in ſome meaſure protected the more weſtern. 38 Roz. 230. 238. And that in general the mountains of this country were ſo diſordered (by the ſhock) that the miners are obliged to work at hazard. Ibid 226. Steller makes the ſame remarks on the mountains of Kamſchatka, 51 Phil. Tranſ. Part ii. p. 479. Storr, Hœpfner & Sauſſure, inform us that the inundation that invaded Swiſſerland proceeded from the ſouth, but its impreſſion was modified by another event which I ſhall preſently mention. 1 Helvet. Magaz. 173. 175. 4 Helvet Magaz. 307. Laſius tells us that the mountains of the Hartz ſuggeſt the ſame inference. Hartz. 95.

4thly, The very ſhape of the continents which are all ſharpened towards the ſouth, where waſhed by the ſouthern ocean, indicate that ſo forcible an impreſſion was made on them as nothing but the mountains could reſiſt, as the Cape of Good Hope, Cape Cormorin, the ſouthern extremity of New Holland, and that of Patagonia; Foſter's Obſervations, p. 11. 12.

To theſe geological proofs perhaps I may be permitted to add the tradition of the orthodox Hindus, that the globe was divided into two hemiſpheres, and that the ſouthern was the habitation of dæmons that warred upon the Gods. 3 Aſiatic Reſearches, 51 & 52. This war is commonly thought to be an allegorical deſcription of the *flood*, and hence the olive branch, denoting a diminution of the flood, became a ſymbol of peace.

Did not Noah reſide on the borders of the ſouthern ocean, otherwiſe he could not ſee that the great abyſs was opened? and did not an inundation from the ſouth-eaſt drive the ark north-weſt to the mountains of Armenia? Theſe conjectures are at leaſt conſiſtent with the moſt probable notions of the primitive habitation of man, which I take to be near the ſources of the Ganges (as Joſephus expreſly mentions) the Bourampooter and the Indus, from which, as the temperature grew colder, mankind deſcended to the plains of India.

This unparalleled revolution Moſes informs us was introduced by a continual rain for forty days. By this the ſurface of the earth muſt have been looſened to a conſiderable depth; its effects may even have been in many in many inſtances deſtructive; thus in Auguſt 1740 ſeveral eminences were ſwept away, nay the whole mountain of Lidſheare, in the province of Wermeland in Sweden, was rent aſunder hy a heavy fall of rain for only one night. 27 Schwed. Abhand, 93. This looſening and opening of the earth was in many places where the marine inundation ſtagnated an uſeful operation to the ſoil ſubſequently to be formed, as by theſe means ſhells and other marine exuviæ were introduced into it which rendered it more fertile. By this rain alſo the ſalt water was diluted, and its pernicious effects both to ſoil and freſh water fiſh in great meaſure prevented. The deſtruction of animals ſerved the ſame purpoſes, and might, in many inſtances, be neceſſary to

fertilize a ſoil produced by the decompoſition of primary mountains; from the animals thus deſtroyed the phoſphoric acid found in many ores may have originated.

But the completion of this cataſtrophe was undoubtedly effected, as Moſes alſo ſtates, by the invaſion of the waters of the great abyſs, moſt probably, as I have ſaid, that immenſe tract of ocean ſtretching from the Philipine iſlands or rather from the Indian continent on the one ſide to terra-firma on the other, and thence to the ſouthern pole, and again from Buenyos Ayres to New Holland, and thence to the pole.—Tracing its courſe on the eaſtern part of the globe, we ſhall ſee it impelled northwards with reſiſtleſs impetuoſity againſt the continent which at that time probably united Aſia and America. This appears to have been torn up and ſwept away (except the iſlands that ſtill remain) as far north as latitude 40°; its further progreſs appears to have been ſomewhat checked by the lofty mountains of China and Tartary, and thoſe on the oppoſite American coaſt; here then it began to dilate itſelf over the collateral countries; the part checked by the Tartarian mountains forming, by ſweeping away the ſoil the deſart of Coby, while the interior or middle torrent preſſed forward to the pole, but the interior ſurge being ſtill more reſtricted by the contiguous, numerous and elevated mountains of eaſtern Siberia and America, muſt at laſt have ariſen to a height and preſſure which over-bore all reſiſtance, daſhing to pieces the heads of thoſe mountains, as Patrin and Steller remark, and bearing over them the

the vegetable and animal ſpoils of the more ſouthern, ravaged or torn up continents, to the far extended and inclined plains of weſtern Siberia, where its free expanſion allowed it to depoſit them. Hence the origin of the bones and tuſks of elephants and rhinoceri found in the plains, or inconſiderable ſandy or marly eminences in the north weſtern parts of Siberia, as Mr. Pallas rightly judges.

If now, returning to the ſouth, we contemplate the effects of this overwhelming invaſion on the more ſouthern regions of India and Arabia, we ſhall, where the coaſts were undefended by mountains, diſcover it excavating the gulfs of Nanquin, Tonquin and Siam, the vaſt Bay of Bengal and the Aarabic and Red Seas. That the ſouthern capes, promontories and headlands, were extenuated to their preſent ſhape by the deluge, and not by tides or the currents ſtill obſerved in thoſe ſeas, may be inferred from the inefficacy of thoſe feebler powers to produce any change in them for many paſt centuries.

The chief force of the inundation ſeems to have been directed northwards in the meridians of from 110 to 200 eaſt of London. In the more weſtern tracts it appears to have been weaker; the plains of India I ſuſpect to have been leſs ravaged, or perhaps their ſubſequent fertility may have been occaſioned by the many rivers by which that happy country is watered. Not ſo thoſe of Arabia; their ſolid baſis, reſiſting the inundation, was obliged to yield its

looſe

looſer ſurface, and remains even now a ſandy deſart, while the interior more mountainous tracts, intercepting, and thus collecting, the waſhed off ſoil, are, to this day, celebrated for their fertility, 2 Niebuhr, 45 and 320. Iriſh edition. To a ſimilar tranſportation of the antient vegetable ſoil, the vaſt ſandy deſarts of Africa, and the barrenneſs of moſt of the plains of Perſia, may be attributed.

The progreſs of the Siberian inundation once more claims our attention; that it muſt have been here for ſome time ſtationary may be inferred from its confinement between the Altaiſchan elevation on the ſouth, and the Ouralian mountains on the weſt, and the circumpolar mountains on the ſide of Greenland. Hence the excavations obſerved on the northern parts of the former, and the abrupt declivities on the eaſtern flanks of the latter, while the weſtern diſcover none. New reinforcements from the ſouth-eaſt muſt at length have ſurmounted all obſtacles; but the ſubſequent ſurges could not have conveyed ſuch a quantity of ſhells or marine productions as the firſt, and hence, though many are found on the more northern *plains*, ſcarce any are found on the great Altaiſchan elevation.

The maſs of waters now collected and ſpread over the Artic regions, muſt have deſcended partly ſouthwards over the deſarts of Tartary, into countries with which we are too little acquainted to trace its ravages, but from the oppoſition it muſt have met in theſe

theſe mountainous tracts, and the repercuſſion of their craggy ſides, eddies muſt have been formed to which the Caſpian, Euxine and other lakes may have owed their origin. Part alſo muſt have extended itſelf over the vaſt tracts weſt of the Ourals, and there expanded more freely over the plains of Ruſſia and Poland down to latitude 52° where it muſt have met with and be oppoſed by the inundation originating in the weſtern parts of the Pacific ocean, this ſide the Cape of Good Hope, and thence impelled northwards and weſtwards in the ſame manner as the eaſtern inundation already deſcribed, but with much leſs force, and ſweeping the continents of South America (if then emerged) and of Africa conveying to Spain, Italy and France, and perhaps ſtill farther North, elephants and other animals and vegetables hitherto ſuppoſed partly of Indian and partly of American origin.

That the courſe here aſſigned is not imaginary appears from the ſhells, vegetables, and animal remains of thoſe remote climates, ſtill found in Europe, and from the diſcovery both of the European and the American promiſcuouſly mixed with each other at Fez. 1 Bergman Erde Kugel, 252. 249.

So alſo in Germany, Flanders and England, the ſpoils of the northern climates, and thoſe of the ſouthern alſo, are equally found; thus the teeth of arctic bears and bones of whales, as well as thoſe of animals of more ſouthern origin, have been diſcovered in thoſe parts.

The effect of the encounter of ſuch enormous maſſes of water, ruſhing in oppoſite directions, muſt have been ſtupendous, it was ſuch as appears to have ſhaken and ſhattered ſome of the ſolid vaults that ſupported the ſubjacent ſtrata of the globe. To this concuſſion I aſcribe the formation of the bed of the Atlantic from latitude 20° ſouth up to the north pole. The bare inſpection of a map is ſufficient to ſhew that this vaſt ſpace was hollowed by the impreſſion of water; the protuberance from Cape Frio to the river of the Amazons, or La Plata in South America, correſponding with the incavation on the African ſide from the river of Congo to Cape Palmas; and the African protuberance from the Straits of Gibraltar to cape Palmas, anſwering to the immenſe cavity between New York and Cape St. Roque. The depreſſion of ſuch a vaſt tract of land cannot appear improbable when we conſider the ſhock it muſt have received, and the enormous load with which it was charged. Nor is ſuch depreſſion and abſorption unexampled ſince we have had frequent inſtances of mountains ſwallowed up, and ſome very lately in Calabria *

The

* The Bay of Galway appears to have been originally a granitic mountain, ſhattered and ſwallowed during this cataſtrophe, for fragments of granite are found on its northern ſhore, though none in the neighbouring mountains, which are chiefly argillitic. Alſo a vaſt maſs of granite called the Gregory, lately ſtood on one of the iſles of Arran, 100 feet at leaſt above the level of the ſea, 10 or 12 feet high, as many broad, and about twenty in length. Though the whole maſs of the iſland conſiſts of compact limeſtone and no granitic hill within 8 or 10 miles of it. This was ſhattered by lightning in 1774.

The wreck of ſo conſiderable an integrant part of the globe muſt of neceſſity have convulſed the adjacent ſtill ſubſiſting continents previouſly connected with it, rent their ſtony ſtrata, burſt the ſtill more ſolid maſſes of their mountains, and thus in ſome caſes formed, and in others prepared, the inſular ſtate to which theſe fractured tracts were reduced; to this event therefore I think may be aſcribed the bold ſteep and abrupt weſtern coaſts of Ireland, Scotland and Norway, and the numerous iſles that border them, as well as many of thoſe of the Weſt Indies. The Britannic iſlands ſeem to have acquired their inſular ſtate at a later period, though it was probably prepared by this event; but the baſaltic maſſes on the Scotch and Iriſh coaſts and thoſe of Feroc appear to me to have been rent into pillars by this concuſſion.

During this elemental conflict, and the craſh and ruin of the ſubmerged continent, many of its component parts muſt have been reduced to atoms, and diſperſed through the ſwelling waves that uſurped its place. The more liquid bitumens muſt by the agitation have intimately mixed with them. They muſt alſo have abſorbed the fixed air contained in the bowels of the ſunk continent; and further, by this vaſt continental depreſſion, whoſe derelinquiſhed ſpace was occupied by water, the level of the whole diluvial ocean muſt have been ſunk, and the ſummits of the higheſt mountains muſt then have emerged. In this ſtate of things it is natural to ſuppoſe that if iron abounded in the ſubmerged continent, as it does

at this day in the northern countries of Sweden, Norway and Lapland adjacent to it, its particles may have been kept in ſolution by the fixed air, and the argillaceous, ſiliceous and carbonaceous particles may have been long ſuſpended. Theſe muddy waters mixing with thoſe impregnated with bitumen, the following combinations muſt have taken place: 1°. If carbonic matter was alſo contained in the water, this uniting to the bitumen muſt have run into maſſes no longer ſuſpenſible in water, and formed ſtrata of coal. 2do. The calces of iron by the contact of bitumen were in great meaſure gradually reduced, and together with the argillaceous and ſiliceous precipitated on the ſummits of ſeveral of the mountains not yet emerged, and thus formed baſaltic maſſes, that during deſiccation ſplit into columns; in other places they covered the carbonaceous maſſes already depoſited, and by abſorbing much of their bitumen rendered them leſs inflammable, and hence the connexion which the ſagacious Werner obſerved between baſalts and coal. The fixed or oxygen air, erupting from many of them, formed thoſe cavities, which being filled by the ſubſequent infiltration of ſuch of their ingredients as were ſuperfluous to their baſaltic ſtate, formed calcedonies, zeolytes, olivins, baſaltines, ſpars, &c. Hence moſt of the mountains of Sweden that afford iron, afford alſo bitumen *. Hence alſo the aſphalt found with Trap † and under baſalts ‡, and in balls of calcedony found in Trap §.

This

* Berg. Jour. 1789. p. 2005.
† Berolding on Mercury, p. 38 and 240.
‡ Von Salis 171. 3. Noſe. 146.
§ 10 Naturforſch. 43.

This I take to be the *laſt* ſcene of this dreadful cataſtrophe, and hence no ſhells are found in theſe baſalts, they having been previouſly depoſited, though ſome other lighter marine vegetable remains have ſometimes been found in them; ſome argillaceous or ſandſtone ſtrata may alſo have been depoſited at this period.

On this account however of the formation of the baſalts which crown the ſummits of ſeveral lofty peaks, I lay no more ſtreſs than it can juſtly bear; I deliver it barely as an hypotheſis more plauſible than many others.

It has been objected to the Moſaic account that the countries near Ararat are too cold to bear olive trees. Tournfort, who firſt made this objection, ſhould recollect, that at this early period the Caſpian and Euxine ſeas were joined, as he himſelf has well proved. This circumſtance ſurely fitted a country lying in the 38th degree of latitude to produce olives (which now grow in much higher latitudes) at preſent chilled only by its diſtance from the ſea.

A more plauſible objection ariſes from the difficulty of collecting and feeding all the various ſpecies of animals now known, ſome of which can exiſt only in the hotteſt, and others only in the coldeſt climates; it does not however appear to me neceſſary to ſuppoſe that any others were collected in the ark but thoſe moſt

neceſſary for the uſe of man, and thoſe only of the graminivorous or granivorous claſſes, the others were moſt probably of ſubſequent creation. The univerſality of the expreſſions, Gen. chap. vi. ver. 19. "Of every living thing, of all fleſh, two of every ſort ſhalt thou "bring into the ark," ſeem to me to imply no more than the ſame general expreſſions do in Gen. chap. i. ver. 30. "And to *every* "beaſt of the earth, and to *every* fowl of the air, have I given "*every* green herb for meat;" where it is certain that only graminivorous animals are meant. At this early period ravenous animals were not only not neceſſary but would have been even deſtructive to thoſe who had juſt obtained exiſtence, and probably not in great numbers. They only became neceſſary when the graminivorous had multiplied to ſo great a degree that their carcaſſes would have ſpread infection. Hence they appear to me to have been of poſterior creation; and to this alſo I attribute the exiſtence of thoſe that are peculiar to America and the torrid and frigid zones.

The atmoſphere itſelf muſt have been exceedingly altered by the conſequences of the flood. Soon after the creation of vegetables, and in proportion as they grew and multiplied, vaſt quantities of oxygen muſt have been thrown off by them into the then exiſting atmoſphere without any proportional counteracting diminution from the reſpiration or putrifaction of animals, as theſe were created only in pairs, and multiplied more ſlowly; hence it muſt have been much purer than at preſent; and to this circumſtance perhaps

perhaps the longevity of the antediluvians may in great meaſure be attributed. After the flood the ſtate of things was perfectly reverſed, the ſurface of the earth was covered with dead and putrifying land animals and fiſh, which copiouſly abſorbed the oxygenous part of the atmoſphere and ſupplied only mephitic and fixed air; thus the atmoſphere was probably brought to its actual ſtate, containing little more than one-fourth of pure air and nearly three-fourths of mephitic. Hence the conſtitution of men muſt have been weakened and the lives of their enfeebled poſterity gradually reduced to their preſent ſtandard. To avoid theſe exhalations it is probable that the human race continued for a long time to inhabit the more elevated mountainous tracts. Domeſtic diſturbances in Noah's family, briefly mentioned in holy writ, probably induced him to move with ſuch of his deſcendants as were moſt attached to him to the regions he inhabited before the flood, in the vicinity of China, and hence the early origin of the Chineſe monarchy.

THIRD ESSAY.

OF SUBSEQUENT CATASTROPHES.

A Shock ſo violent and univerſal as that which pervaded the globe during the diluvian revolution muſt have produced not only innumerable alterations in the whole extent of its ſurface

ſurface endleſs to detail (and belonging rather to the natural hiſtory of its particular geographic diviſions than to a general ſurvey of the whole) but alſo have prepared, by looſening its baſis, many other changes that took effect ſome centuries after, as I have already hinted; of theſe however ſome are ſo important by their connexion either with the paſt tranſactions of the inhabitants of the globe, or with the actual external appearance or ſubterraneous ſtate of the countries with which we are beſt acquainted, that they cannot be totally paſſed over in ſilence; ſuch are the total ſeparation of Aſia from America, the coarctation of the Baltic, the ſeparation of the Caſpian from the Black Sea, and the junction of this with the Mediterranean and of the Mediterranean with the Ocean, and laſtly, the ſeparation of Ireland from Britain and of Britain from the Continent.

These events are either totally omitted by hiſtorians, or only ſlightly mentioned by that hiſtory from its mixed nature ſtiled *fabulous;* in ſuch caſes imagination has commonly taken up the pen of the hiſtorian, but poſſeſſing neither the inclination nor the talents neceſſary for converting natural hiſtory into *romance*, the account I ſhall give of them muſt be very ſhort, and ſuch as is ſuggeſted by the moſt probable traditions or actual appearances.

1º. Of the ſeparation of Aſia from America we have no tradititional account; it is certain however that they were once joined,

joined, as the inhabitants of the former paſſed into the latter; they ſtill approach each other very nearly in the northern parts, and the intermediate ſpace is filled with iſlands. The junction immediately after the flood I ſtated in my former Eſſay to have reached ſo low as latitude 40°, becauſe I find America peopled by nations of different characters, degrees of civilization and languages; ſuch varieties could ſcarcely occur among a people inhabiting the ſame climate and formed to the ſame habits. As Cain was originally baniſhed from his brethren, ſo I imagine malefactors anciently were into the colder deſerted climates by their civilized brethren in Aſia, and thus the Eſquimaux originated that are equally found in both continents and other ſavages; and hence the prædatory diſpoſition of the Scythian tribes. That the poſtdiluvian junction did not reach lower than latitude 40° I infer from the abſence of elephants from the warmer regions of America.

The utter ſeparation of both continents was moſt probably the effect of excavations by volcanos; at leaſt this cauſe is adequate to ſuch an effect, and it ſtill exiſts in the moſt northern parts. The ſuperior fertility of the weſtern coaſt of America may ariſe from the lavas ejected on that coaſt.

2d. That the Baltic in all its branches was anciently much more extended than at preſent many reaſons induce us to believe;

lieve; but principally the ſtate in which we at preſent find the immenſe plains of Southern Ruſſia from Peterſburgh to Pultowa.

These plains for ſome hundred miles to the ſouth of Peterſburgh are ſtill a moraſs, and farther ſouthwards they are covered with ſand, pebbles and petrified ſhells*. This water is not indeed ſalt, but neither was the Baltic ſo originally, and is but ſlightly ſo at preſent, for it ſeems to have been formed by the confluence of the various rivers that flow into it, which at laſt burſt a paſſage into the German ſea, by communication with this it became ſalt. At preſent there are three paſſages by which they communicate, at firſt probably but one; to the opening of the two laſt the reduction of this ſea to its preſent limits is owing.

3d. The ancient communication between the Caſpian, the Lake of Aral and the Black Sea, before the opening of the Thracian Boſphorus, which enabled theſe ſeas to diſcharge themſelves into the Mediterranean, is rendered highly probable if not demonſtrated by Pallas, 3 Pallas Reiſe 368. He obſerved that between the rivers Sarpa and Volga, from Zarzycin down to the Caſpian ſea, the land ſlopes with conſiderable indentures and abrupt promontories as

* Schwed. Abhand. 1773, 181, &c. 2 Bergm. Erde kugel. 215.

as if it had been an ancient coaſt, and continues on the ſame level on the eaſt of the Wolga in the ſandy deſert of Narym and in the more ſouthern ſteppes or deſerts betwen the Wolga and the Jaick or Ural. The ſhells which abound in this extenſive *flat* exactly reſemble thoſe of the Caſpian and are different from thoſe of the adjacent rivers; theſe deſerts are moreover covered with ſand, contain abundance of ſalt and ſalt lakes, and produce only ſuch vegetables as grow on ſalt marſhes; whereas the upland that borders this flat contains a genuine black fertile ſoil, and no ſhells reſembling thoſe of the Caſpian, but only thoſe of ancient date, ſuch as thoſe found in other countries, and of the ſorts called *Pelagicæ* that belong to the deepeſt ſeas. Hence he collects that the level of the Caſpian before it was reduced to its preſent limits was ninety feet higher than at preſent; thus it was enabled to communicate with the Euxine by the ſea of Aſoph. In this ſtate it muſt have remained from the period of the deluge until about 1800 years before our Æra, the moſt probable date of the ſeparation of theſe ſeas, as Mr. Foſter has ſhewn in a learned memoir in the Gottingen Magaz. 1780, p. 140.

Buffon pretends the rupture of the iſthmus that ſeparated this ſea from the Mediterranean preceded the deluge mentioned by Moſes, merely it ſhould ſeem to contradict that moſt authentic hiſtorian, for he aſſigns no reaſon independent of his

own hypotheſis and is deſtitute of the ſupport even of the moſt fabulous tradition. 1. Epoques. 8vo. p. 291.

The rupture of the iſthmus was probably ſudden and total, and conſequently effected by an earthquake. To diſcover its effects, we muſt firſt conſider the antecedent ſtate of the Mediterranean:

The Mediterranean, before its union with the Black Sea and the Ocean, was moſt probably a baſon much narrower and ſhallower than at preſent; for though it received ſeveral conſiderable rivers, the Nile, the Rhone and the Po, yet ſince even now evaporation from its ſurface is ſufficient to prevent it from overflowing, notwithſtanding that the Ocean on the one ſide and the Euxine on the other flow into it, we may well ſuppoſe that when it communicated with neither, evaporation kept its level much lower; when therefore by the rupture of the Thracian Iſthmus on the one ſide, and of the African which joined Ceuta with Gibraltar on the other, the waters of both were poured in upon it, an immenſe preſſure took place on its bed, under which it ſunk and fell into the inferior cavity of the globe; during this tremendous tumult the iſlands of Sicily, Sardinia, Corſica and thoſe of the Archipelago were torn off, and Italy was lengthened to its preſent ſhape. The neighbouring ſhores of France and Spain, and more eſpecially thoſe of Africa as being much lower,

and

and thoſe of Greece and Aſia, muſt have been inundated to a great extent, and hence the ſaline ſubſtances ſtill exiſting in the adjacent parts of Africa, &c.

As the ſouthern parts of Italy ſtill abound in ſulphur and other inflammable ſubſtances, ſo probably did the contiguous parts of the bed of the Mediterranean, and by the immenſe friction which they muſt have ſuffered during this fall and the hollows that interceded the abrupted maſſes the firſt ſubterraneous fires might have been kindled and the beds of the actual volcanos prepared, which however did not probably acquire ſufficient ſtrength to burſt through the incumbent earthy ſtrata until ſome ages after, as I conjecture from the ſilence of Homer with reſpect to Etna, whoſe wonders had they exiſted in his time he probably would not have overlooked.

The ſeparation of Sicily from Italy is vouched by ancient traditions, as may be ſeen in Pliny, Ovid and Claudian.

Zancle quoque juncta fuiſſe
Dicitur Italiæ, donec confinia pontus
Abſtulit, & media tellurem reppulit unda. *Ovid Metam. Lib.* 15. *v.* 290.
Trinacria quondam
Italiæ pars una fuit, ſed pontus & œſtus

Mutavere ſitum, rupit confinia Nereus
Victor, & abſciſſo interluit æquore montes. *Claudian. De Rapt. Proſerp. Lib.* 1.

The ſteep abrupt coaſts from Genoa to Leghorn, deſcribed by Ferber in his twenty-ſecond letter, muſt be aſcribed to the rupture of the ſtrata, as tides, ſcarcely ſenſible in this ſea, cannot be even ſuſpected of having acted ſo powerfully upon them. The rapidity of the Rhone and of moſt of the rivers that fall into this ſea on the European ſide alſo indicate the great inclination of the ſtrata of the interior countries towards it, a natural conſequence of the depreſſion of their primitive ſupport. The mountains of Swiſſerland diſcover alſo veſtages of a ſhock on the ſouth eaſt, as I have already noticed, the detail of which I leave to the many excellent geologiſts of that country.

The communication of the Euxine with the Ocean by means of the Mediterranean being thus formed, its level gradually ſubſided, the canal which joined it with the Caſpian dried up; as few great rivers fall into this (only the Wolga and the Ural) it was ſoon reduced by evaporation to its preſent level, which is ſaid to be lower than that of any other ſea, and thus the ſalt deſerts that border it, were formed, and its ſeparation from the Aral effected.

5° The

5° The entire ſeparation of Great Britain from the Continent muſt have happened long after the deluge, and that of Ireland from Great Britain at a ſtill later period; for wolves and bears were anciently found in both, and theſe muſt have paſſed from the Continent into Britain and from this into Ireland, as their importation cannot be ſuſpected. Theſe events as I already ſaid muſt have been prepared and have commenced by the ſhock communicated during the rupture and depreſſion of the bed of the Atlantic. The divulſive force that ſeparated Britain from Germany ſeems to have been directed from north to ſouth, but gradually weakened in its progreſs, Hence that iſland is ſharpened to the northwards, but the impreſſion muſt have been conſiderably weakened by the oppoſition of the granitic mountains that form the Shetland and Orkney Iſles. The looſer ſtructure of the calcareous or argillaceous and arenaceous materials of the more ſouthern parts offered leſs reſiſtance, was more eaſily preyed upon, and gave way to what is now called the German ocean, while theſe materials themſelves were ſpread over Weſtphalia, &c. or formed the ſubſoil of Flanders, Holland and the ſand-banks on its coaſt. The rupture of the iſthmus that joined Calais and Dover was probably effected by an earthquake at a later period, and gradually widened by tides and currents. Ireland was protected by Scotland from the violence of the northern ſhock, hence its ſeparation from Scotland appears to have been late and gradual. That from England was probably diluvial and effected by a ſouthern ſhock.

All

All theſe changes happened at leaſt three thouſand ſix hundred years ago, and I ſee no reaſon to think that the general level of the ocean has ſince been altered, but that of the continents ſeems to have varied conſiderably, being in ſome places higher and in others lower than anciently.

The depreſſion of continents originates from two cauſes, the firſt is the diminution of the waters that anciently pervaded them; the ſecond is the ſliding away of the inferior argillaceous ſtrata; to ſay nothing of cauſes merely contingent, as earthquakes and inundations.

After the deluge, the earth on which it reſted 150 days, and from which it very ſlowly retired, muſt have been drenched with water; vegetation quickly enſued, and twenty centuries ago moſt countries are known to have been covered with trees, and many until a much later period; in theſe circumſtances an infinity of ſmall rivulets muſt have been formed, which poured their ſtreams into the great rivers ariſing from their confluence; while the ſurface of the earth was protected by foreſts from the immediate influence of the ſun, the moiſture repleniſhing its interior muſt have remained. Again, as we ſee the craggy ſummits of many of the higheſt mountains, now decompoſing, being corroded by air and moiſture, we muſt ſuppoſe that the ſame cauſes have operated in the moſt ancient times, and that previous to their action theſe ſummits were much

much higher, and conſequently better fitted for collecting vapours than at preſent, but in modern times, from the extenſion of agriculture to countries where it never before was introduced, and the increaſing multiplication of mankind, the foreſts have in great meaſure diſappeared; the earth laid bare yields its waters to evaporation; the mountains lowered, no longer collect or condenſe the ſame quantity of vapour, the rivulets ceaſe, or are reduced to rills, and the earth freed from its pervading moiſture has naturally ſunk to a lower level. Hence moſt rivers were anciently much more conſiderable than at preſent, as we may ſee by the wide extended vales through which they run, the monuments of their ancient magnitude. Not only bogs have in ſome inſtances been known to ſlide over lower adjacent plains, but even portions of land ſeemingly more ſolid. Thus in France near Meudon in 1787 a whole ſide of a hill covered with trees deſcended 50 feet upon and covered to the height of 70 feet a neighbouring plain; its deſcent laſted ſix years. 43 Roz. 19. It was occaſioned by laying bare a bed of clay which by imbibing rain was tumefied and looſened. In Bohemia alſo, ſo late as the year 1770, a great part of the mountain of Ziegenberg ſlid down 38 fathom to the Elbe with its trees ſtill ſtanding partly erect and partly inclined. This was aſcribed to the ſolution of its inferior ſtratum, an argillaceous ſandſtone, whoſe argillaceous part was carried off by rain to which it had incautiouſly been expoſed. Reuſs *Bohemia*, 55.

In ſome places the ſurface of the earth has been elevated by the particles carried down by rain from greater elevations, or the gradual diſintegration of the ſtony ſubſtances that covered them, or by various local and contingent events. Hence many remains of antiquity depoſited on the ancient ſurface are now found at conſiderable depths, particularly in countries long devaſted.

The effects of volcanos in altering the face of the globe ſeem to me much more circumſcribed than many late writers have aſſerted: few mountains, and thoſe eaſily diſtinguiſhable, owe their origin to them; neither Veſuvius nor Ætna were formed by them, as is evident by the maſs of Neptunian ſtones that compoſe them; their effuſions ſeldom reach to a great diſtance, none above 100 miles. Of ancient volcanos now extinct, few can be traced by undoubted characters or hiſtoric accounts. Sidonius Apollinaris, Lib. 7. Epiſt. 1. mentions one near Vienne in Dauphiné which burned about the year 469; but by his account it is not clear whether it was a volcano or a pſeudo volcano; I ſuſpect the latter.

Tacitus alſo, at the end of the 13th Book of his Annals, mentions a volcano, or rather pſeudo volcano, that ravaged the country of the Jutiones; this is ſaid by many to be that of the Ubians; if ſo it muſt have been in the neighbourhood of Cologn, where ſome pſeudo volcanic remains are traced.

On

On no ſubject have philoſophers been leſs cautious of the deluſions of imagination than on this of volcanos: the aſtoniſhment excited by their awful phœnomena ſeems to have affected even the underſtanding of ſome of their ſpectators. The author of many celebrated treatiſes on volcanos, lately travelling into Scotland, exclaimed, at the ſight of every black ſtone he met with, that it was *lava*, as I was informed by one of his companions *; even the very excellent Sir William Hamilton has frequently been ſeduced from the ſimple path of obſervation to which notwithſtanding he profeſſed to adhere, into the mazes and errors of a baſeleſs ſyſtem †. In a letter to Sir John Pringle, May 1776, he tells us that "Wherever baſaltic pillars like thoſe of the Giant's Cauſeway in "Ireland are found there without doubt a volcano muſt have ex-"iſted, for they are mere lava." At preſent however I believe none will pretend that the volcanic origin of theſe pillars is out of the reach of doubt. He tells us that Veſuvius and Ætna were formed by a ſeries of volcanic eruptions ‡, though there is no certain proof that the former was ſo formed, and it is demonſtrable that the latter exiſted as a mountain before it became a volcano. Padre Torre, who has given a good deſcription of Veſuvius, inſiſts that its primitive ſtamina, if I may ſo call them, are not volcanic, but that it ſhould rather be conſidered as an extenſion of the Appenines; the number

 of

* Mr. Macie, a gentleman of the moſt exact and extenſive mineralogical knowledge.
† Ouvres de Hamilton, p. 10.
‡ Ouvres de Hamilton, p. 11.

of Neptunian ſtones it throws up, as may be ſeen in Gioeni's Lithography of Veſuvius, confirms this opinion; that the calcareous ſtrata are covered to a great depth with lava cannot be doubted, but that the whole maſs of Veſuvius conſiſts of volcanic ejections has not been proved; it is ſaid that in ſinking a well near the ſea ſhore beds of lava, have been found at great depths, but how eaſily may have the mother ſtones of lava, hornblende and ſhiſtoſe hornblende be miſtaken for lava itſelf?

With reſpect to Ætna there can be no doubt. Dolomieu found immenſe heaps of ſea ſhells in its north-eaſt flanks at the height of near 2000 feet over the ſurface of the ſea. Hence he juſtly concludes that this volcano exiſted as a mountain before it was uncovered by the ſea; he adds that at the height of about 2400 feet there are regular ſtrata of grey clay filled with marine ſhells; theſe ſtrata muſt then have been depoſited while the mountain was a forming under the ſea; it contained alſo he ſays priſmatic lava, but the word *lava*, particularly with the addition *priſmatic*, can now impoſe on no one *.

He farther affirms that in particular parts of this mountain, calcareous ſtrata exiſt under the lava.—So alſo Count Borch, in his Letters on Sicily and Malta, informs us that the original ſtone of which Ætna conſiſts is granite mixed with jaſper, neither of which

* Ponces, 465. 466. &c.

which ſurely are lava, he ſays that it abounds in *mines* of lead and copper, neither of which are ever found in lava, though their fragments may. This laſt mentioned geologiſt pretends that Ætna is at leaſt 8000 years old, which he infers from the beds of vegetable earth whch he diſcovered betwixt different beds of lava. Yet Dolomieu expreſly tells us that ſuch earth does not exiſt between beds of lava, *Ponces* 472. and thus deſtroys the foundation of thoſe calculations that aſcribe to the globe an antiquity incompatible with the Moſaic hiſtory. Even if vegetable earth were found betwixt beds of lava, yet no concluſion relative to their age could fairly be deduced from that circumſtance, as ſome lava become fertile much ſooner than others. Thus Chevalier Gioanni in 1787 found lavas projected in 1766 in a ſtate of vegetation, while other lavas much more ancient ſtill remained barren. Dolom. *Ponces* 493. And in particular, it is well known that beds of volcanic aſhes and pumice vegetate ſooner than any other *.

I HAVE been led into this detail by obſerving how fatal the ſuſpicion of the high antiquity of the globe has been to the credit of the Moſaic hiſtory, and conſequently to religion and morality; a ſuſpicion grounded on no other foundation than that whoſe weakneſs I have here expoſed. M. Dolomieu tells us that Canon Recupero denied having ever expreſſed any doubt on that head,

* Ferber Italy, 169.

and could not conceive why a late celebrated traveller ſhould endeavour to render ſuſpicious the orthodoxy of his belief. So far from having been perſecuted on that account, he had a penſion from the court of Naples to his death, with many teſtimonies of eſteem and regard. *Ponces*, 471.

SYNOPTICAL VIEW *of the* STATE *of the* WEATHER *in the Year* 1796.

By RICHARD KIRWAN, *Esq; L. L. D. F. R. S. and M. R. I. A.*

	BAROMETER.					THERMOMETER.			RAIN.		STORMS.	
1796.	Highest	Day it happened.	Lowest.	Day it happened.	Mean of the Month.	Highest in the Day.	Lowest at Night.	Mean of the Month.	Days.	Inches.	No.	
January - -	30.32	6th W by N.	28.76	23d. SE. S. and SW.	29.583	58. –	32. –	48. –	18	2.778371	9	SW. S.W.& NW.
February - -	30.66	26th E.	28.92	5th W. and SW.	29.966	52.5	32.5	41.784	17. 2 of which fell snow.	1.103473	1	NW. W. SW.
March - -	30.70	20 & 21st E. and NE.	29.72	30th var. S. to N. & NW.	30.216	56. –	29.5	41.767	11. and 3 fell snow.	–.827604	–	
April - -	30.52	8, 25 & 26th E.	29.24	30th SE. S.	30.211	67. –	35.5	49.849	12	1.103473	–	
May - -	30.42	23d E. NE.	28.87	30th S. & W.	29.909	64 –	35. –	50.741	20	4.335074	1	S by W.
June - -	30.57	30th W.	29.77	1st & 2d var. E. S. & SW.	30.147	73.5	41. –	56.392	20	1.497570	1	Var. SW. S. SE. and W. by N.
July - -	30.46	1st var. S. W. & NW.	29.47	5th SW. & NW.	29.913	72. –	44. –	57.782	25	2.837502	3	SW.
August - -	30.62	15 & 16 NE. E. to W.	29.86	1st W.	30.29	72.5	44. –	59.71 –	11	–.275867	–	
September -	30.47	29th & 30th NW. & E.	29.52	20th E. to S.	30.123	72.5	45. –	58.387	16	1.891 1668	1	W by S.
October - -	30.70	27th E.	29.28	6th NW. to S.	30.113	66. –	30. –	47.13 –	16	–.867014	–	
November -	30.60	26, 27 & 28th E. N. & NW.	29.45	16th var. SW. & NW.	30.057	59. –	24.5 –	39.942	15	1.274242	1	W by S.
December -	30.70	10th W.	29.17	29th SW.	30.01	53.5	20. –	35.438	20. 5 of which fell snow.	3.15078	2	SE.
Mean of the Year	30.561		29.336		30.044			48.847	204. on 10 of which there fell snow.	21.942136 Total of the Year.	19. Total in the Year.	

THE mean temperature of this year was ſtill lower than that of the laſt, but the exceſs was chiefly in the ſix firſt months.

THE greateſt height of the barometer, namely 30.7, happened three times, ♈ : ♓ : in March, October and December.

THE hotteſt days were in June, July and Auguſt, the heat did not exceed 73°.5.

THE coldeſt night was December 24th ♈ : ♓ : 20°.

THE wetteſt month, as to the quantity of rain, was May; as to the number of rainy days, was July; but on the whole there fell much leſs rain than uſual during this year, not quite 22 inches: the two drieſt months were March and October.

View of the Seaſons.

SPRING.	Rain. Inches.	Days.	SUMMER.	Rain. Inches.	Days.	AUTUMN.	Rain. Inches.	Days.
April -	1.1034	12	June - -	1.4975	20	September -	1.8911	16
May -	4.3350	20	July - -	2.8375	25	October -	.8670	16
	5.4384	32	Auguſt -	.2758	11		2.7581	32
				4.6108	56			

HENCE

HENCE we ſee the Spring was *wet*, the Summer *variable wet*, the autumn *dry*.

Compariſon with the Rules of Probability.

THE Spring being *wet* the probability of a wet Summer was the greateſt, and that of a variable wet Summer the next greateſt; the firſt $\frac{5}{8}$ the other $\frac{4}{8}$ by the 6th table.

THE Spring being wet and the Summer variable, the probability of a dry Autumn was the greateſt by the 10th table.

THE obſervation that the more it rains in May the leſs it rains in September was alſo remarkably verified this year, it rained ſtill leſs in October.

BUT the obſervation that the abſence of ſtorms in March prognoſticates a dry Summer was falſified this year.

FOR ſome years paſt I have remarked that a change of weather moſt commonly happens on the 7th, 14th and 21ſt of every month, a day before or a day after, but ſometimes though rarely the weather continues for three or four of theſe periods.

Of

Of the Winter preceding the Seaſons of 1796.

1795.	Rain.	Days.	Mean. Barom.	Heat.
November - -	2.8506	17	30.02	41
December - -	2.3908	21	30.01	44
			30.015	42.5
1796.				
January - -	2.7783	18	29.58	48
February - -	1.1034	17	29.96	41.7
March - -	0.8276	11	30.21	41.7
	9.9507	84	29.916	43.8

THERE the rain was not even half of that which fell in the Winter of 1795, and yet the Summer was alſo variable wet.

SUPPLEMENT *to* MR. EDGEWORTH's ESSAY *upon the* TELEGRAPH.

SINCE the Royal Iriſh Academy did me the honour to accept of my eſſay on the telegraph, I have made material improvements in its conſtruction, which I think it my duty to communicate. Read Dec. 3, 1796.

IN September 1796, the Lord Lieutenant ordered me to prepare telegraphs for an experiment before his Excellency. In conſequence I conſtructed four new telegraphs—I had found that the large machines thirty feet high, with which my ſons talked in September 1794 acroſs the channel, between Ireland and Scotland, were liable to accidents in ſtormy weather: my firſt conſideration therefore was to contrive ſome means of furling their canvas when they were not in uſe; and from the rigging of ſhips it was obvious that cordage was for this purpoſe preferable to inflexible braces of wood. I therefore adopted the following conſtruction:

A. (fig. 4.) A hollow axle-tree, made in ſeparate pieces, hooped together in the form of a double truncated cone, on the midlde of which is faſtened a wheel of wood (b. fig. 4.) with eight notches cut out (a. fig. 4.) to receive eight ribs (r. r. r. r. r. r. r. r. fig. 1. and 2.) Theſe ribs turning on a ſtrong iron ring, ſhut up like the ribs of an umbrella, and are raiſed and adjuſted by cords paſſing through eight holes in the flanches or ſhoulders (F. fig. 1. 4.) Theſe flanches, and thoſe at (f. fig. 2. and 4.) ſerve to keep the machine in its place upon the ſtands which ſupport it (fig. 2.) the cords are ſtrained and faſtened like the cords of a tent (c. c. &c. fig. 2.)

Where permanent buildings are not required, ſupports for theſe machines may be conſtructed in the following manner: Two ſtands, each of them made of two pieces of wood ſimply bolted together as (fig. 3.) muſt be erected, and held ſteady by means of cords (c. c.) faſtened to common tent pegs as in (fig. 2. P. P. P.) When the machines are large, ſmall piles ſhould be uſed inſtead of pegs, and running tackle (t.) ſhould be uſed both for the cords of the pointers and the ſtands. A number of minute circumſtances ſhould be attended to in the conſtruction and uſe of theſe machines; but I do not think it proper to detail them to this Academy; they ſhould appear in a different place (*a*).

Besides

(*a*) Formerly in France every engineer, who conducted any public work, was obliged to lodge in a public office exact drawings with minute deſcriptions of every part of and proceſs of his operations. Numberleſs ſmall improvements in workmanſhip

Besides rendering the telegraph ſafe againſt ſtorms, and more eaſily manageable, I found by experience that one machine could be made to perform the ſame effect as four, with but little loſs of time; what took up four minutes with four pointers can be conveyed in five minutes by one. I have alſo found, that by anſwering each ſignal or number ſhewn at every ſtation, all poſſibility of miſtake is avoided.

I believe that in other eſtabliſhments of this ſort it has been found that thick and foggy weather has occaſioned more interruptions than were expected. With my telegraphs I have good reaſon to aſſert that there do not commonly occur above eight or ten days in the year when intelligence might not be conveyed by land.

If eight men were poſted at each permanent ſtation, at the diſtance of eighteen or twenty Engliſh miles aſunder, with machines of twenty-five feet high, in hazy weather, they might detach two men with portable telegraphs to the diſtance of about ſix miles from each ſtation, who with eight foot telegraphs could keep up a regular communication.

manſhip and tools were preſerved by theſe means, and by degrees were collected into publications of general circulation.

I was required to deliver drawings of all the machinery I employed in the work carried on at Lyons in 1772 for turning the courſe of the Rhone.

But in the tranſactions of a literary ſociety ſuch details would be tedious and improper.

The portable telegraph reſembles that which I have deſcribed It differs only in two circumſtances; for convenience, as it is ſmall and does not oppoſe much ſurface to the wind, it may be diſtended with ribs of wood inſtead of cords.

The portable telegraph which my ſon had the honour of ſhewing to His Royal Highneſs the Duke of York in Kenſington Gardens in October laſt, was furniſhed with ſilken cords, on purpoſe to ſhew how my larger telegraphs were conſtructed; but it was intended merely for reconnoitring near an army, and was only ſix feet high.

In the eſſay which the Academy has already received I ſaid that imitations without end might be made of my telegraph. Every index or pointer that moves circularly, dividing an imaginary circle into parts and denoting figures or ſigns that correſpond with a vocabulary, is founded on the ſame principle as mine. The French have laid aſide their former clumſy apparatus, and have conſtructed a telegraph on theſe principles; and the admiralty in England have as I am informed very lately done the ſame.

The firſt pointers I employed in 1767 were wind-mill ſails. I then tried indexes of the ſhape (fig. 5.) Fig. 8. A pointer like a ſword-cutler's ſign was recommended to me by a member of the Academy, as a ſecond or additional hand to move on the ſame

ſame center as the principal hand. But a triangle, whoſe baſe is equal to half its ſide, is of all the figures I have tried the moſt diſtinct.

The night-telegraph remains ſtill to be deſcribed; its uſes are perhaps more extenſive than thoſe of the telegraphs I have already publiſhed; and I propoſe to make it the ſubject of another paper upon a future occaſion.

The art of conveying ſwift and ſecret intelligence is not one of thoſe inventions which attracts attention only by its novelty; on the contrary I am convinced that it will be thought more valuable the longer it has been ſubmitted to the teſt of time and experience.

A DESCRIPTION *of an* AIR-PUMP *of a* NEW CONSTRUCTION, *with an* ACCOUNT *of its* PERFORMANCE, *and of ſome* EXPERIMENTS *and* OBSERVATIONS *tending to aſcertain the* CIRCUMSTANCES *on which the* PERFECTION *of that* MACHINE *depends, and to render its* THEORY *more compleat. By the Rev.* JAMES LITTLE *of Lacken in the County of Mayo.*

Read Dec. 17th 1796.

THE many diſcoveries which have done honour to the exertions of the electricians and chemiſts, even ſince the middle of this century, encourage us to hope that their labours will not terminate 'till they become the means of affording to poſterity a more extenſive knowledge of the latent principles and powers of nature, and conſequently a more devout conviction of the wiſdom of its great Creator, than there was any proſpect of in the preceding age. Such knowledge of the works of God, ſought out of all them that have pleaſure therein, and affording unexpected advantages to human life, is the reſult of experimental enquiry; and experiments cannot be made without proper inſtruments

ments and machines. Of theſe, none has opened a wider field of enquiry in natural philoſophy than the air-pump; and I am inclined to think, that this inſtrument has not yet afforded all the ſervices of which it is capable, when I conſider that air is ſo large a component part of moſt bodies, that ſince many kinds of air are compounded of other aeriform fluids, and aſſume different qualities according to the varieties of their combination, theſe component fluids would in many experiments be with moſt advantage united in vacuo; and alſo that ſome electrical experiments not only require a vacuum, but alſo one of the moſt perfect kind.

With a view to this latter circumſtance ſolely, ſo long ago as the year 1776, I ſet about contriving an air-pump which ſhould be ſimple in its conſtruction and yet exhauſt more perfectly than thoſe of the common form; and in 1778 I made one (the barrel of which was of pewter-metal) on the principle, which, I was ſatisfied from the following theory, was the moſt eſſential, of leaving as little air as poſſible under the piſton when put down to the bottom of the barrel; and the performance of this machine was ſo excellent as to induce me to fabricate a larger and more perfect one of the ſame conſtruction, and made in braſs-metal, which I had executed (in the country) in the year 1785; but not finding it to perform as well as I had expected, I deviſed an alteration and improvement in it, which I had almoſt finiſhed the workmanſhip of in 1788, being that

which

which is here deſcribed; and from that time 'till the laſt ſummer (1785) it lay by me neglected, bad health, &c. diverting my attention from it; for the whole of it, except the forging the iron-work, was made by myſelf without aſſiſtance. At length, being loth to loſe my labour, I put the laſt hand to it. Before it was finiſhed, I was acquainted with the conſtruction of Mr. Smeaton's air-pump, with its improvements, but had not heard of Mr. Cuthbertſon's; which, as well as Mr. Smeaton's, I find is conceived on the ſame principle with mine, yet the application of that principle in the machine here deſcribed, being exhibited in a much more ſimple conſtruction, it will I am perſuaded be found to perform better and with more certainty than the former, on which perſuaſion only I am induced to publiſh it. The reader will eaſily underſtand what is hereafter ſaid of its theory, after he has conſidered its conſtruction.

The principal parts of it are one barrel and piſton, one ſtop-cock, one valve, and two pipes of communication.

N. B. The pump here deſcribed is a portable one, and ſo contrived as to be confined in a very ſmall ſpace; but it may be made of a different form, and with two barrels, though not conveniently.

Fig. 1. is a perſpective view of the whole machine as it lies before the operator. Fig. 2. is a back-view of the ſame.

The barrel A A, (fig. 1.) is almoſt fifteen inches long, and internally in diameter juſt two inches; it is moſt perfectly cylindrical, and poliſhed like a looking-glaſs within. The piſton (fig. 3.) is ſolid, without any perforation; it conſiſts of circular plates of leather preſſed together between the round plate *a*, (in the ſocket of which *b*, the piſton rod was inſerted and faſtened by a croſs ſcrew, before the leathers were put on) and the two upper plates *c* and *d*; of which the outer one *d*, being ſcrewed upon a ſcrew formed on the outſide of the ſocket, preſſes down the under plate, and this the leathers, which latter are not repreſented in the figure. The upper plate, when ſcrewed on, lies even with the upper part of the ſocket, that, when the piſton is raiſed to the top, it may touch the plate covering the upper part of the barrel, leaving no air above the piſton. Theſe two plates of the piſton, eſpecially the lower one, are made ſo large as juſt to move in the barrel without touching it, and care was taken that when the piſton is put down, it ſhould be every where in contact with the plate at the bottom of the barrel, this plate being turned in the lathe upon the piſton rod which fitted its ſocket exactly, ſo that not the leaſt ſpace might be left for lodgment of air under the piſton. The leathers are of the beſt buck-ſkin, dreſſed in the uſual manner, firm in its texture, but not harſh; and being well dried, were ſoaked in a mixture of three parts ſuet melted with one part oil, before they were put together: they

Fig. 5.

Fig. 3.

Fig. 4.

Fig. 1.

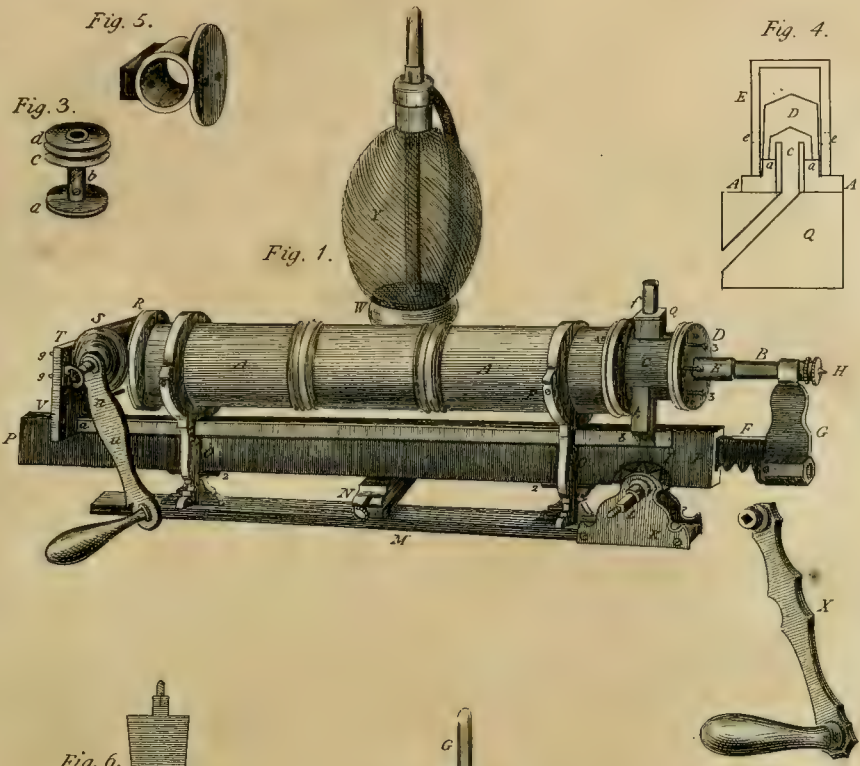


Fig. 6.

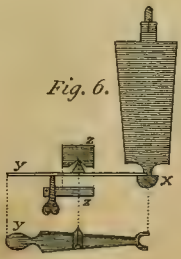
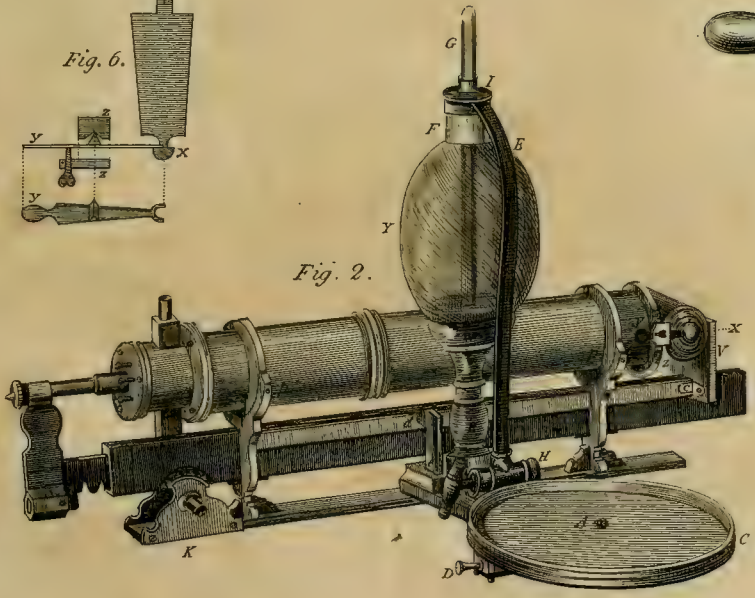


Fig. 7.

Fig. 2.



they were then, when cold, turned in a lathe on the piſton, with a very ſharp tool *.

The iron rod of the piſton is $\frac{45}{100}$ths of an inch in diameter, exactly cylindrical, and very ſmoothly poliſhed; it moves through a collar of leathers (the ſame kind as thoſe of the piſton) encloſed in the braſs box C, the lower plate of which is fixed on the top of the barrel by the four ſcrews 4, 4, paſſed through the broad prominent rim of it; and the plate was ſo well adapted to the top of the barrel, by grinding it on it with a circular motion, as to require only the interpoſition of a little ſtiff ointment to make the joining air-faſt. A cover is, in the ſame manner, adapted by three ſcrews to the projecting rim of the box containing the collar of leathers, in the middle of which cover is fixed the ſocket or collar E, above an inch long, through which the piſton rod moves. As it is altogether neceſſary that this rod ſhould move moſt

 exactly

* If tanned leather were uſed for the piſton, &c. it might be ſoaked in oil alone; beſides that it is apt to grow too hard by compreſſion, and alſo to corrode the braſs of the barrel more from the acid imparted by the bark with which it is tanned, it alſo emits a greater quantity of elaſtic fluid in vacuo than leather which is not tanned. On theſe accounts I have uſed buck-ſkin leather for the piſton, but the texture of this being very looſe, oil only would not fill its pores ſo as to make the piſton air-tight, even when the leathers were cloſely preſſed; and it was neceſſary to fill its grain with the above ſtiffer compoſition. Yet this leather will alſo generate air, and is harder to be made air-faſt; it alſo moves ſo ſtiffly in the barrel that perhaps good ſhoe-leather is preferable to it.

exactly in the middle or axis of the barrel, care was taken that the position of the box, and of the ſocket annexed to it, ſhould be ſecured, by having a prominent part of the plate of the box of leathers inſerted into the pump barrel, and a like projecting part of the lid of the box inſerted into the box itſelf; alſo that the piſton rod ſhould moſt exactly fill the ſocket in the lid. Over the collar of leathers, within the box, lies a tinned braſs plate, which is preſſed down upon them by the ends of three ſcrews 3, 3, ſcrewed through the lid of the box.

The piſton is moved up and down by the toothed flat bar or rack F, whoſe end is furniſhed with an arm G, (to be taken off occaſionally) which arm is ſecured againſt a ſhoulder formed on the end of the piſton rod, by a nut H ſcrewed on the rod; the rack is moved by a ſmall ſteel wheel L, one inch and $\frac{7}{10}$ in diameter, having twelve teeth, and which is turned by the handle X fixed on its axis L. This wheel is ſuſtained by the cheeks K, K, fig. 1. & 2. furniſhed with projecting ſockets, through which its axis paſſes. Theſe cheeks are ſcrewed to the iron bar M, which is a part of the frame ſupporting the whole machine; by this bar it is faſtened by clamps to whatever table it is placed on. From the middle of the bar, and at right angles with it, extends horizontally an arm N, (rivetted and brazed upon the bar) the under

under ſurface of the arm being on a level with the upper one of the bar; this arm ſupports the gage glaſs Y, and terminates in a croſs piece (making together the form of the letter T) to which piece and to the arm, the receiver-plate is ſcrewed by ſcrews underneath, inſerted into its thick margin.

The bar M ſupports the upright pieces or pillars o, o, terminating in the ſemicircular arms p, p, on which the barrel is faſtened by four ſcrews at p, p, ſcrewed a little way into its projecting rings. Theſe pillars are made of iron, and very ſtrong, being half an inch in thickneſs; they are alſo moſt firmly fixed, and ſhould be brazed in the bar which ſupports them; this being neceſſary, as all the force of the handle of the wheel, by which the rack is worked, bears againſt theſe pillars; and, if they were to be ſhaken, the cement by which the receiver pipe is connected with the pump would be broken, which cannot otherwiſe happen. The pillars ſupport alſo the iron caſe or ſheath P P, extended underneath the pump barrel, within which caſe ſlides the toothed bar or rack F, moved by the wheel, and this rack (with its caſe) is fixed exactly parallel to the axis of the cylinder, that it may draw out the piſton rod preciſely in that direction in which itſelf moves: the bar is $\frac{3}{10}$ of an inch in thickneſs, but is an inch in breadth from the bottom of its teeth to the back of it. It is made thus ſtrong that the end of it may not be ſtrained upward

upward from the proper direction, when it is urged forward by the wheel, and yet checked by the piſton rod after the piſton is raiſed to the top of the barrel. To confine the rack in the true line of its motion, it is made perfectly ſtraight and of the ſame dimenſions in its whole length, and its caſe the ſame, ſo as to fit each other moſt exactly, that it may be kept in its due poſition when the greateſt part of it is drawn out of the caſe; for which purpoſe alſo it is made (as likewiſe the caſe) ſo much longer at either end than the part neceſſary to be toothed, as to permit a great part of it to remain in the caſe when the piſton rod is drawn out to its utmoſt extent: accordingly, in this pump, it acts in this reſpect as well as could be wiſhed *. A notch is cut out of the caſe at I, to allow the teeth of the wheel to take into thoſe of the rack; and to keep the caſe firmly in its place, little notches are cut in the upper edge of it, into which the contiguous parts of the pillars are let, and it is ſecured ſo by wedges 2, 2, underneath. It will be known that the caſe of the rack has its due poſition when, the arm G being taken off, both the rack and the piſton rod, pulled out to their limit, are

* By this contrivance of fixing the barrel of the pump horizontal and its rack underneath the barrel, it is made ſo portable that I have packed it (the gage glaſs and receiver being taken off) in a box two feet long, eighteen inches wide and ſeven in depth; and it ſhould be remembered, that the moſt operoſe parts of it here deſcribed are the frame and machinery neceſſary to render a pump with *ſo long a cylinder* portable; a great part of which machinery, if it were not portable, would not be ſpared, but merely exchanged for the huge frame of thoſe ſo conſtructed.

are found to be parallel. The pillars are made as ſhort as poſſible; to favour which, the frame M has a furrow cut in the middle of it under the wheel I, to let the teeth of the wheel deſcend almoſt to the table on which the machine reſts; and the pump barrel is placed as near as may be to the rack.

On the upper part of the box containing the collar of leathers, is a projecting part of the metal, in the ſhape of a cube, forming a little pedeſtal Q: on this is placed the valve f; from beneath which deſcends a ſtraight duct into the barrel without penetrating the box: the form of the parts of this valve (all made of braſs and of the ſize of the originals belonging to the pump) is repreſented in fig. 4. in a vertical ſection. A A is a ſquare plate (to be taken off, if it ſhould require to be ground and poliſhed anew in contact with the valve;) which is faſtened on the pedeſtal with cement; it has a hole in the middle, being the opening of the duct, in which is inſerted the little elevated pipe *c*, to be occaſionally taken out; whoſe uſe is, to prevent the oil applied to the valve from being blown down into the duct, by the air ruſhing into the barrel: the elevated part of the plate *a a* is circular, and has its upper ſurface made plane and poliſhed, on which reſts the valve D; which is ſo far hollowed within, that only its lower edge, being about $\frac{1}{30}$th of an inch thick, (which is alſo well poliſhed) may be in contact with the plate under it, and alſo that its cavity may riſe above the little pipe:

pipe: the valve is almoſt cylindrical, tapering but a little from the baſe upward, and being laid on the plate with a ſmall drop of oil interpoſed, the hollow cylindrical cap E, very little wider internally than the valve, is put over it, being faſtened down on the projecting circular part of the plate *a a*. To let the air paſs through this cap, three little holes *e*, *e* are made in its ſides, the centers of which are juſt as high as the lower edge of the valve D, when it is raiſed to touch the top of the cap; the holes being higher than the plate under the valve, that the oil may not run out by them. When this valve is found to admit air into the barrel, it is occaſioned either by the oil's being blown away, or ſome particle of duſt, &c. getting between it and the plate, (which would produce the ſame effect in any valve) and is remedied by taking it off, wiping it clean and applying another drop of oil: the greater the quantity of air is, which paſſes by the valve, the more is the oil diſſipated, and conſequently this chiefly happens in the beginning of the exhauſtion, when much air is drawn from the receiver, and thrown out of the barrel at each ſtroke; ſo that whenever great rarefaction is requiſite, I often found it convenient towards the end of the operation to apply a freſh drop of oil to the valve, keeping the piſton in the mean time elevated to the top of the barrel whilſt the valve is taken off, until it be replaced; which is done in an inſtant: thus it will perform perfectly well, if quite clean and free from duſt; but as the ſmalleſt particle of dirt or mucus (which is apt to be produced from the oil's corroding the

the braſs and becoming clammy) will render the valve not air-tight, I am therefore perſuaded that no valve will ſo perfectly or certainly exclude air as a ſtop-cock; and this I take to be the chief reaſon why Mr. Smeaton's pump, as improved by Meſſrs. Kaas's and Hurter's contrivance for raiſing the valve at the bottom of the barrel, does not in practice anſwer as well as any other: for if ſome air did not return into the receiver by that valve, in pumps on his conſtruction, it would be hard to tell why it ſhould not perform as well as a pump of any other conſtruction.

To the bottom of the barrel is faſtened, by four ſcrews paſſed through its prominent rim, the circular plate R, forming, in part, the ſhell of the cock S, and which has the high ridge T on the back of it; all theſe being only one piece of metal, which is repreſented ſeparately in fig. 5, and was caſt in that form: the round plate is about $\frac{1}{4}$th of an inch thick, but the cavity of the cock intrudes ſo far on this that, when the key of the cock is put in, the thickneſs of the plate in the part directly over the key, where the ducts open into the barrel, is not more than $\frac{1}{8}$th of an inch: the length of the ſhell of the cock is three inches; that of the key $\frac{1}{8}$th of an inch leſs: the diameter of the key at the thicker extremity is 1 $\frac{4}{10}$ths of an inch, and at the ſmaller end 1 $\frac{1}{4}$th of an inch. It is turned by the handle *u*, faſtened on its axis as near to the end of the ſhell as may be, viz. at the diſtance of $\frac{1}{4}$th of an inch. Care

was taken that the metal of the cock ſhould be free from pores, by which if air were admitted in the working, it would be very hard to diſcover it, as this might take place only in *certain poſitions* of the key; and the ointment might ſometimes prevent and ſometimes ſuffer it, ſo that it might elude trials; the cock was alſo ſo truly and ſmoothly ground as to produce an intimate contact of the key and ſhell throughout, (for air will penetrate where liquids would not) it was alſo made of a true conical ſhape, its ſides being perfectly ſtrait from end to end. The cock muſt be lubricated and made air-tight by ointment *, and as all oil or greaſy ointment has an acid in it, (of which perhaps it can never be diveſted without deſtroying its lubricity) which corrodes the braſs, and ſtiffens the oil or ointment itſelf, by impregnating it with green ruſt or verdegris, I found it neceſſary, after the cock was finiſhed, to have the key and the inſide of the ſhell coated with tin †.

THE

* This I have made of one part common roſin, one part oil, and one part and a half freſh ſuet: the oil and roſin is firſt melted, and when a little cooled, the ſuet is added, that the heat requiſite to melt the roſin may not burn the fibrous part of the ſuet and deſtoy its firmneſs: more oil is to be added in cold than in warm weather. The quality of the ointment for the cock is of the utmoſt conſequence; for if ever the parts of the metal of the cock come into immediate contact, it will not be air-faſt; oil will not render it ſo, (nor conſequently would a valve) but the ointment muſt be ſtiff and adheſive; yet not too ſtiff, as then it would be hard to turn the key, and it could not be diſtinguiſhed whether its ſtiffneſs was owing to the ointment, or to the friction of the parts of the metal getting into immediate contact, which would be pernicious.

† This was done by making the metal very clean and bright by rubbing with whiting and water; and having heated it as hot as boiling water, and preſerved it ſo,

The key of the cock terminates in a little knob *x*, fig. 2. againſt which the end of the thin ſpring lever *y*, preſſes to keep the key conſtantly firm in its ſhell: this ſpring is made to urge onward the key with any degree of force requiſite, by the ſcrew at *y*, ſcrewed through the outer part of the little arch or frame, which frame is itſelf faſtened by ſcrews on the prominent ring of the barrel, as appears at *z*, fig. 2. The lever has a little ridge or elevated part, which reſts in a notch in the frame; by which the lever is fixed in its proper place, the notch being the fulcrum: by withdrawing the ſcrew, the ridge may be raiſed out of the notch, and the lever pulled back from the knob, to let the key be taken out when it requires more ointment; which will be known when it has worked into the ſhell nearly to its limit; and this ſhould be

ſo, I rubbed the parts to be tinned very well for half an hour, or more, with a linen rag wetted with diſtilled vinegar, in which had been boiled ſome ſalammoniac, together with an amalgam of quickſilver and tin; 'till the metal was every where well coated with the amalgam; then wiping off the looſe particles, I heated the metal in the fire, 'till in the dark, it was juſt beginning to appear red hot; with this heat the mercury evaporated, leaving a very hard coat of tin on the metal, without in the leaſt injuring its ſhape or poliſh; this alſo prevented the key and ſhell of the cock from tearing one another by friction, which would certainly ſpoil the cock, as frequently happens with ſoft braſs.

The inſide of the barrel (for reaſons hereafter given) ſhould be tinned in the ſame manner; but it ſhould, before it is at firſt poliſhed, be heated equally red in the fire, and ſuffered to cool equally and gradually, that it may not alter its ſhape when heated again in tinning. Any other method of tinning it, but this, would be both difficult and hazardous.

carefully learned, by marking how far it can be inſerted into the ſhell without any ointment interpoſed. The form of the key and its lever is exhibited in fig. 6. in an horizontal ſection through the middle of them.

THROUGH the ſhell of this cock are two round perforations for two ducts through the cock, each, one inch diſtant from the other, and the ſame from the end of the cock on either ſide: they are in a plane or ſection paſſing through the axis of the key, and alſo through the axis of the barrel; and both paſs through the ridge of metal T, at the back of the ſhell. The duct next the ſmaller end of the key (being a part of the duct communicating with the receiver) is in diameter $\frac{1}{4}$th and the other duct is only $\frac{1}{8}$th of an inch: through the key alſo are ducts anſwering to the perforations in the ſhell; but the ducts in the key are not both in the ſame ſection of it, but one of them is at right angles to the other; ſo that when one of the ducts through the cock is open, the other will be always ſhut, and vice verſa.

THERE is a continuation of each of thoſe ducts formed in the piece of metal V, which is joined (by cement interpoſed) to the ridge of the ſhell of the cock by four ſcrews *g*, *g*, fig. 1, by two openings (into the two ducts in the piece of metal) oppoſite to thoſe in the ridge; and theſe ducts in the piece

piece V, have two other orifices at *a* and *c*, where the two pipes *a b*, fig. 1, and *c d*, fig. 2. communicate with the two canals in the piece of metal, being connected with them only by the help of cement, that the barrel with its cock may be occaſionally disjoined from them: thus a ſeparate communication is formed between each of the pipes and the barrel.

The pipe *a b*, is only $\frac{1}{10}$th of an inch in diameter, except at its orifices which are widened; one of them is connected at *b*, with a duct formed in the piece of metal *k*, attached to the box of leathers C, at the top of the barrel, which duct turning in an angle, without penetrating the box, opens into the barrel: this pipe and duct are joined by a ſimple application of their orifices, which are made in the contiguous ſides of both, and the joint made air-tight by cement melted around with a blow pipe; and the ſame might be effected by the preſſure of a ſcrew cloſing the ſurfaces, with oiled leather interpoſed. By this pipe, when the valve is ſhut, and the key of the cock ſo placed that the communication of this pipe with the bottom of the barrel is open, if the piſton be depreſſed from the top, all the air which is *under* it will be forced to paſs, by this pipe, into thebarrel *above* the piſton; and vice verſa, if the piſton be elevated from the bottom; ſo that according to the motion of the piſton, the air under or over it within the barrel is made to change its place, and to circulate from the

the ſpace under or above the piſton, to the contrary; from which effect of this pipe, I call it the *circulating pipe*.

The other pipe or duct is repreſented at *c d*, fig. 2, which exhibits a back view of the pump: its extremity *c*, enters the block of metal V, to communicate with the duct therein, and ſo with that through the cock into the barrel: its end *c* has a wing ſoldered to it, by which it is firmly ſcrewed to the piece V, this being neceſſary, leſt the cement, by which alone the joint there is made air-faſt, ſhould be cracked by any ſhock moving the barrel; or it might perhaps be ſecured by the ſcrew with only leather interpoſed; this duct is a very wide one, that the air may the ſooner paſs through it; it has a turn at right angles at *d*, and another at *e*, from whence it extends under the pillar B, and pump-plate C D, through the middle of which it riſes at A; it has a branch turning at right angles from A, under the pump-plate, the end of which terminates in a round orifice with an inſide ſcrew, that by means of a pipe, furniſhed with a ſtop-cock, or otherwiſe, another pump-plate and receiver, or ſeveral of them, may be connected with it, being laid on the ſame table which ſupports the pump: when ſuch are not uſed, the orifice is cloſed with a ſtop-ſcrew as at D. From this pipe riſes a branch E, inſerted into the top of the braſs cap F of the glaſs veſſel Y, and opening into the veſſel by a duct made in the thick plate of the cap. G, is a reduced barometer tube to be filled

filled in the moſt perfect manner with mercury, and immerſed into a pool of mercʸ in the bottom of the glaſs veſſel. The interval between the tube and the neck of the veſſel is cloſed by cement, which, as the neck muſt be a good deal wider than the tube, is effected by a deep ring (I) fitted to the tube, having a round plate at the bottom of it; which being let down on the tube, after it has been immerſed in the ciſtern, is joined with cement to the top of the cap. The tube was eaſily immerged in the mercury within the veſſel, by covering its open end, and ſuſtaining the mercʸ in it by a little plate or ſcale of iron (P) fig. 7. having two threads tied to it through two holes made near its edges; which threads were graſped together with the top of the tube between the fingers, and the tube was inverted and let down into the mercʸ in the veſſel: the little plate was then pulled up by one of the threads, it being made ſo ſmall as to paſs through the neck of the glaſs while the tube was within it and remained immerſed in the mercʸ *: the veſſel was then cloſed at the top with melted cement; and as it communicates by the pipe E with the conduit pipe, it is exhauſted with the receiver, and the mercʸ in the tube will ſink as the rarefaction advances: if a perfect

* I thought this the beſt way of fixing the reduced barometer, for if there were a ſeparate veſſel, as a ciſtern, for the mercʸ, and a receiver placed over it and the tube, the eye, when on a level with the ſurface of the ſtagnant mercʸ, could not ſee the altitude of that in the tube, with preciſion, through two glaſſes.

fect vacuum could be made in the rec^{r} and gage-veſſel, it would ſink more or leſs *beneath* the level of the ſurrounding merc^{y}, as the tube is narrower or wider, even ſo as to diſappear, if the tube were very narrow; ſo that it muſt not be leſs than $\frac{3}{10}$ths of an inch in diameter; but it would be better if it were $\frac{4}{10}$ths. If it were obſerved how much the merc^{y}, in a tube open at both ends, would ſink beneath the level of that in a ciſtern, in the open air, it might be pretty nearly eſtimated how great is the rarefaction in this gage veſſel and conſequently in the rec^{r}.

This reduced barometer is the ordinary gage I uſed, by which a perſon accuſtomed to obſerve it may know what is nearly the rarefaction when it does not exceed two or three thouſand times; for which purpoſe there ſhould be marks made with a file on the outſide of the tube, dividing it into inches and decimal parts: if the common whole barom^{r} gage, and this reduced one, were applied to the pump together, the altitude of the merc^{y} in the latter would be equal to the difference between that of the former and a ſtandard barom^{r}. When the merc^{y}, having ſunk to the bottom of this ſhort tube, riſes to the top again on admiſſion of air, all the inviſible air bubbles which were in it, will aſcend and form one air bubble at the top, which will be the leſs, and the gage the more exact, as the tube had been more perfectly filled, and this will alſo ſhew how far the ordinary Torricellian vacuum is from being

ſo

ſo perfect as it is commonly ſuppoſed, for there will perhaps always be ſuch an air-bubble formed, be the tube ever ſo carefully filled: in that mentioned in the ſubſequent trials however, the bubble was not bigger than a pin's point, and ſcarce viſible.

If after exhauſtion the air were let ſuddenly into the recr and gage-veſſel, the mercy would be forced up into the tube with ſuch violence as certainly to knock the top off it, or to ſplit it; to prevent which, the cock is placed at H, to ſtop the communication of the recr duct with the branch of it which goes to the gage-glaſs, whenever it is requiſite to let air ſuddenly into the recr: when this cock is not ſhut, the communication between the recr and gage-veſſel muſt never be opened, (if the latter has been exhauſted and the mercy has ſubſided in the tube) 'till the piſton is previouſly put down to the bottom, and the recr is exhauſted. It would be a great improvement of this machine, if another ſuch cock were placed between this one and the recr, to ſtop occaſionally the main duct between the barrel and recr; by which the recr would be doubly fortified againſt the intruſion of air, and the cock attached to the barrel might then have its key taken out, when it requires freſh ointment to be applied; which will often be neceſſary, when it muſt be turned many times during the exhauſtion of a large recr, or when one is to be kept exhauſted many days, and it may be requiſite frequently in that time to pump out air which

might have forced an entrance into the recr. This can't be done in my pump here deſcribed for want of this ſecond cock, which might at firſt have been eaſily added.

The gage-glaſs or veſſel is ſupported by the pillar B, which is ſo high, as that the eye of the operator, looking over the barrel, may be on a level with the ſurface of the mercy in the gage-veſſel; it terminates in a deep cup W, to receive the narrow bottom of this veſſel, which is fixed in it with cement: the pillar is fixed upon the duct of the recr by two ſcrews which paſs through the iron frame underneath, and alſo through the ſides of the duct, which are ſo thick as to admit holes for the ſcrews to be made through them, without the channel of the duct; by which both the pillar and the duct are made firm.

If a ſyphon-gage ſhould be preferred to the reduced barr, this pillar would ſupport it, and the pipe E might be connected with its open end. I have preferred the former, becauſe in it the foul, confined, or factitious air, which may be in the recr, can never get into the tube, and make its ſides and alſo the mercy in it foul, preventing its motion in the tube and equilibrium; as it ever will do in time in the ſyphon or common barr gage; ſo that this little baromr always acts as well as at firſt. To apply a whole barr as a gage to this pump, when

when placed on a common table which is too low; let a metal pipe connected with the rec^{r} at C, or D, fig. 2. have an arm riſing upwards to the height neceſſary to connect it with the open top of the bar^{r} tube, whoſe ciſtern may be ſupported by a board faſtened below to the frame of the table. Thus every neceſſity will be prevented for conſtructing the pump with an unportable frame.

In order to make each of the ducts, which have now been deſcribed, communicate alternately with the barrel, it is neceſſary that the key of the cock ſhould receive a motion of one quarter of a turn, the ducts in it being at right angles to each other; and conſequently it muſt have detents to confine it to that motion: this is effected by a pin *n*, fixed perpendicularly in the back of the handle *u*, fig. 1. which pin, when the handle is put on the ſquare end of the key (and ſecured there by a winged nut) deſcribes a quadrantal arch under the ſhell of the cock, where there is juſt room to allow ſuch a motion of the pin, a part of the ridge of metal at the back of the cock, being hollowed out for that purpoſe; and care was taken that the ducts in the key, when at the limits of its due motion, exactly correſponded with the holes in the ſhell; the key not being pierced 'till the handle was fittted on, and theſe limits aſcertained. The joinings of the cock to the barrel, and

of the piece of metal to the cock, as alſo of the ducts to that piece of metal, are made air-tight by melted cement interpoſed between them *.

THE

* The parts to be joined were firſt made very clean and bright, and then heated ſo much as to melt the cement quite fluid; ſome of it being thus ſmeared on the whole of the ſurfaces which were to be applied together, before they were joined; as otherwiſe it would not penetrate into an extenſive joint, eſpecially if the metal were too cold, for the cement would grow ſolid in its paſſage; nor would it intimately cohere with either glaſs or metal leſs hot. The cement I uſed for this purpoſe was made of about two parts of common reſin and one part bees-wax, melted together, which anſwered well enough: this I alſo melted, with an iron moderately hot, round the edges of the recr on the plate, both being previouſly warmed; when I wanted the recr to be permanently air-faſt, or when from its ſides being too weak or of an improper ſhape, there was danger that being exhauſted, its ſides might change their form by the great preſſure of the external air, in which caſe ſofter cement would, by yielding, admit air.

Whenever it is neceſſary to open the barrel to clean it, the piſton is to be firſt raiſed to the top, the nut to be then unſcrewed from the end of the piſton rod, the arm of the rack to be taken off, and the ſcrews faſtening the box of leathers to the end of the pump, to be taken out; then with a hot iron, or rather a candle and blow pipe, melt the cement joining the circulating-pipe to the piece of metal attached to the box, (or unſcrew them if joined by a ſcrew.) The box of leathers may then be taken off, and the piſton extracted, which, with the barrel, &c. being cleaned, the parts may be replaced without disjoining any other part of the pump. N. B. The leathers of the piſton having been at firſt treated as before directed, freſh hog's-lard would be beſt to lubricate its edges with, afterwards; for if oil were uſed for this purpoſe (at leaſt copiouſly) ſome of it would get into the holes of the cock, and making the ointment of it too ſoft, it would admit air. Alſo after ointment has been put on the cock, and the key has been often turned to ſpread it evenly, the key, before the pump is worked, muſt be taken out; and the mouths of the ducts in it, cleared of the ointment by a pin, and alſo of thoſe in the ſhell, by a crooked wire. This is neceſſary to any pump conſtructed with a cock in place of a valve.

The action of this pump in exhauſting is as follows: The piſton being at the bottom, and the key of the cock turned to its limit on that ſide by which the communication is open between the barrel and rec^{r}, and conſequently that with the circulating pipe cloſed, the piſton being then raiſed to the top of the barrel, diſcharges the air in it through the valve, and that in the rec^{r} ruſhes into the barrel; the key being now turned to its limit on the other ſide, the communication with the rec^{r} is cloſed, and that with the circulating pipe opened; while it is kept ſo, the piſton is depreſſed, and drives the air (which had paſſed from the rec^{r} into the barrel, and was left there on turning the key, and ſo cloſing the communication between it and the rec^{r}) into the circulating pipe, and through it into the top of the barrel: the piſton being down to the bottom, and the key again turned to open the paſſage to the rec^{r} and to cloſe that with the circulating pipe; if the piſton be again raiſed, the air above it will, as before, be thrown out by the valve, which air is no other than what in the former ſtroke, had come out of the rec^{r}: for the valve at the top cloſing, as ſoon as the piſton began to deſcend, excluded all entrance of the external air into the barrel. As the piſton riſes, more air will paſs from the rec^{r} into the barrel under it, which on turning the key, and depreſſing the piſton, is by the circulating pipe conveyed to the top of the barrel, to be pumped out through the valve on raiſing the piſton as before. Thus the ſtrokes being

ing repeated, ſome air will come every time from the recr into the barrel, 'till that in the recr is as rare as the air in the barrel would be, when the piſton is raiſed to the top; ſuppoſing no communication to exiſt between the barrel and the recr, nor any more air to be under the piſton when elevated to the top, than there was when it was at the bottom.

This pump acts likewiſe as a condenſing engine, without any other additional apparatus than that common to all; of a frame for keeping down the recr, which in this ſhould conſiſt of an iron bar to be laid under the frame ſupporting the recr plate; in which bar are faſtened two upright rods, with nuts and ſcrews at their ends, to ſcrew down a croſs-piece preſſing down the recr in the uſual manner. When the bar is thus laid under the recr plate, this latter will ſtill be level; for the part of the iron frame of the machine which is under the recr plate, is higher than that part under the barrel by which it is faſtened with clamps to the table, as before deſcribed; and when the frame of the condenſer is not uſed, a piece of board ſhould be laid under the recr plate to raiſe it to an horizontal poſition.

The action of this pump in condenſing is as follows: The cock of the gage-veſſel is ſtopt that it may not be burſt; the valve is taken off; the communication of the bottom of the barrel

barrel with the circulating pipe opened by the key of the cock, and the piſton raiſed to the top; the external air then preſſes through this pipe into the bottom of the barrel, which it fills: on opening the rec^{r} pipe by turning the key (which ſhuts the other pipe) and depreſſing the piſton, the air under it is forced into the rec^{r}. The cock being again turned while the piſton is kept at the bottom, and this again elevated, the external air fills the barrel by the circulating pipe as before, and this on turning the key and depreſſing the piſton, as in the former ſtroke, is forced into the rec^{r}; and the condenſation is in this manner encreaſed by a repetition of the ſtrokes; the degree to which it is carried being eaſily known, even without a gage, by knowing the proportion between the capacity of the barrel and rec^{r}, which the operator ſhould, whether he is exhauſting or condenſing, be always certainly informed of, as otherwiſe he cannot tell how many ſtrokes are requiſite to produce a given degree of rarefaction or condenſation; in which latter operation the full of the barrel of air of the natural denſity, is thrown into the rec^{r} at every ſtroke; a dangerous operation with a glaſs rec^{r}, eſpecially when large, unleſs it is cloſely graſped in a cage of metal rods.

To let air ſuddenly into the exhauſted rec^{r}, there is a pin faſtened in the end of the rec^{r} duct (at N, fig. 1.) with cement, by pulling out or looſening which, the air is admitted.

I HAVE

I HAVE been thus particular in deſcribing not only the ſtructure of this pump but alſo the reaſons of the form of each of its parts, and the circumſtances on which depends their right performance: becauſe the ſtructure of the machine is novel; and alſo that any artiſt who might make ſuch a one, may be guarded againſt any alteration not duly conſidered; and as no perſon will ever make exquiſite experiments with an air-pump unleſs he is himſelf, qualified to underſtand and to rectify little accidents and derangements, to which every machine muſt be liable, which is to reſiſt ſo ſubtil an intruder as air; ſo I am ſure neither artiſt nor experimenter (for whom alone this is written) will think me tedious in guarding him againſt miſtakes, which it would be more tedious to diſcover, and far more ſo to correct: in truth to make this deſcription as uſeful as I wiſh, the operator ſhould underſtand the particulars which are mentioned underneath *.

I PROCEED

* Suppoſing every part of the pump to have been made of metal without pores; and that every part and pipe has been ſeparately tried, by being filled with condenſed air, and ſo plunged under water, to ſee if the air eſcapes through any ſecret pore; the barrel alſo joined with its cock, and with the piece of metal attached to it, being thus tried in itſelf, after cloſing the mouths of the ducts in the latter, and that every part in itſelf is found air-tight; if then the machine when put together, is found to to be leaky, it muſt be ſo either in the joints, which are cloſed only with cement, or in the cocks, the valve, or piſton; and to diſcover where the air intrudes, (and difficult indeed will it be found to exclude it altogether) each part may be tried thus: The valve being taken off, put the piſton down to the bottom, and cloſe the bottom by

I PROCEED now to explain the principles on which the pump here deſcribed was conſtructed, and they are theſe:

1ſt, THAT the rarefaction produced in the recr will be by the final action of any pump, if there be no obſtacle to the air's

by turning the key ſo as to reſt at the middle between its limits on either ſide by which both its ducts will be ſtopt, then elevate the piſton, and have it fixed ſo, by putting a bit of wood acroſs between two of the teeth in the rack, which will hinder its deſcent: after a long time, if the piſton when let down, can touch the bottom of the barrel, no air is admitted by the piſton. This being aſcertained, each of the ducts are next to be tried; in order to which, ſtop the hole of the recr pipe in the pump-plate; exhauſt the gage-veſſel, and ſtop its cock, and the barrel cock: if then the mercy riſes in the tube, the glaſs-veſſel itſelf admits air by its cap or duct; which being rectified, open the communication of the gage with the recr pipe by turning the gage-cock; if the mercy ſhould then riſe after a good while, the air has entered at the joint of the recr pipe. Theſe parts being ſecured; then, to try the circulating pipe; firſt exhauſt the gage-glaſs; ſtop the end of this pipe at the top of the barrel, by disjoining it from the box of leathers, and interpoſing a thin plate of metal between its opening and the part *k*, of the box; melt cement about the edges of this little plate, to ſeal up the orifice of the pipe there, having *previouſly* put down the piſton to the bottom; then after opening the communication of the barrel with the recr, mark the height of the mercy; elevate the piſton a little, and keeping it ſo for a good while that whatever air may have entered by the circulating pipe may diffuſe itſelf into the barrel, (to allow which this pipe muſt now communicate with the barrel) turn the key very ſlowly and cautiouſly, to let this air paſs into the gage-glaſs without endangering its tube, and depreſs the piſton to the bottom, when if any air had intruded by the pipe, the mercy will riſe above its altitude before marked, ſhewing that the joint of the pipe with the piece attached to the barrel cock, was leaky; which being remedied, reſtore and ſecure the communication of the pipe with the top of the barrel; exhauſt the gage-glaſs, at the laſt ſtroke of which proceſs, when the piſton is at the top, keep it there, 'till you have ſealed with a plate and cement

air's paſſage, the ſame as that which would be in the cylinder, when the piſton is elevated from the bottom to the top, ſuppoſing there was no communication between the recr and cylr during ſuch elevation; ſo that if there were a perfect vacuum made in the cylr *per ſe*, by raiſing the piſton, the rarefaction in

the hole under the valve; open the communication between the circulating pipe and the barrel, then turn the key back again, and depreſs the piſton to the bottom; obſerve where the mercy ſtands; turn the key, to join the circulating pipe with the barrel; raiſe the piſton half way and keep it ſo a conſiderable time; then ſlowly open the recr duct, and put down the piſton; if the mercy riſes higher than the mark, air has got in either by the piſton rod, its collar of leathers not having been cloſe enough preſſed to the bottom of the box; or by the top of the pump not cloſed; or by the joint of the circulating pipe with the duct in the box; each of which muſt be examined. If the valve admits air, it will be known by being raiſed during the elevation of the piſton before it gets to the top, when the air has been greatly rarefied in the recr, or when both the ducts are cloſed by the key.

If it be choſen to let the air gradually into the recr without looſening the pin, it may be done with ſafety to the tube of the gage-veſſel, by taking off the valve; and raiſing the piſton half way, 'till the barrel under it is filled with air of the natural denſity; then let the cock be *half* turned, and the piſton raiſed to the top, to rarefy the air under it; the cock may then be cautiouſly turned 'till the air gets into the recr, the piſton being afterwards put down to force into it what air remains under it: this may be repeated.

If the piſton rod moves ſtiffly through its collar of leathers it will be eaſed by ſmearing the rod all around with ſome oil. The joints, &c. may be made air-faſt, by melting the cement on them with a blow-pipe, or by a knob of metal, fixed on the end of a wire, heated by a blow-pipe.

The cock of the gage-veſſel (and all others uſed) ſhould have the key one inch and $\frac{3}{4}$ long, and its mean diameter $\frac{1}{4}$ of an inch at the leaſt. It cannot be too carefully formed and poliſhed.

in the rec^{r} would indefinitely approximate to a vacuum; and of conſequence,

2dly, That the degree of rarefaction in the rec^{r} can never exceed ſuch rarefaction in the cyl^{r}: from both which it follows,

3dly, That the moſt perfect pump, $c : p$, is that in which the moſt perfect vacuum is made under the elevated piſton, in the cyl^{r} unconnected with any thing elſe.

The firſt poſition is in fact ſelf-evident, if it be admitted that the elaſticity of the air is as its denſity (and I have reaſon to believe it has elaſtic force to expand itſelf 30,000 times;) for thus, whilever there remains any air, it will have power to diffuſe itſelf out of the rec^{r} into the cyl^{r} (if there be no valve to raiſe, nor any thing to oppoſe its paſſage) ſo long as there is leſs air in the latter than in the former.

The ſecond poſition (or conſequence rather) is no leſs evident; to ſuppoſe the contrary, is to ſuppoſe that a leſs elaſtic force could overcome a greater, or that the rarer air in the rec^{r} could ruſh into the denſer in the cyl^{r}, which is ſo manifeſtly abſurd, that it is ſurprizing the firſt idea of an air-pump which would ſtrike any one, ſhould not be that which firſt occurred to me, when I thought of making one; that no air

ſhould be left under the piſton when put down; yet this was certainly not adverted to by Mr. Boyle, nor (which indeed I admire) by Doctor Hooke, who aſſiſted in contriving for him the firſt air-pump; for Mr. Boyle complains that he could not, uſing recs of any ſize, make the mercy ſink in his baromr-gage to the level of that in the ciſtern, and he attributes this to air caſually intruded, when he might have ſeen that he left it behind in his pump at every ſtroke; for it is manifeſt from the deſcription and figure given of it, that a conſiderable ſpace was left between the bottom of the cylr and the cock; in which air of the natural denſity would reſt, and for ever limit the degree of exhauſtion; now had this been corrected, his air-pump would exhauſt as perfectly as any ſince made, as will appear hereafter. All who have not attended to this circumſtance *, I ſuppoſe, have imagined, that the air left under the piſton could after paſſing into the recr be extracted from it again; whereas on the contrary, if we ſuppoſe a perfect vacuum in the recr, and an imperfect one in the cylr, from air left behind at every ſtroke and diffuſed in it, this air would at each ſtroke get into the recr, juſt for the ſame reaſon that in oppoſite circumſtances, it paſſes out of the recr into the cylr, viz. that it is rarer in the latter: to expect the contrary, is to expect it would miſtake the way it ſhould go.

As

* Mr. Smeaton was too ſagacious not to attend to it.

As it is uſeleſs to attempt to make this plainer *, I proceed to explain the meaſures taken to diminiſh the quantity of air left under the piſton, in this pump, at each ſtroke.

Suppose the cyl^{r} to be open at the top, or the valve to be taken off, which is the ſame thing; then, as the piſton fits the bottom of the barrel, there is no ſpace left for lodgment of air under it when it is put down and the communication with the ducts is ſhut, except the two little cavities in the plate at the bottom, being the holes of the ſhell of the cock lying over the key; and theſe will be always full of air of the common denſity, at the inſtant when the pump communicates with the rec^{r}, for the external air preſſes into the top of the barrel, which is ſuppoſed open, and therefore into the end of the circulating pipe which opens there; conſequently as the piſton cannot be put down, unleſs the air under it, which it protrudes in its deſcent, be diſcharged through this open pipe, ſo the outward air having acceſs to it, and to the bottom of the barrel (with which it muſt communicate during the whole deſcent of the piſton) will fill it and any void under the piſton; but when the piſton is at the bottom, and the key is turned, the air in the pipe is cut off from that in the bottom of the barrel, none almoſt remaining there, but what is in the little cavities over the key; which air will paſs into the rec^{r} on opening its duct into the barrel;—but if, by a *half* turn of the key ſtopping *both* ducts,

* I have proved this by calculation, and it will be farther explained hereafter.

ducts, this air be impriſoned in the barrel and the piſton be then raiſed to the top the air in the cavities will be expanded in the cyl^r, and whatever is its rarefaction then, no greater can ever be produced in the rec^r; but its denſity then will be to what it was when confined in the cavities, reciprocally as the ſpaces occupied, or as the contents of thoſe cavities to the whole content of the cyl^r, that is, the rarefaction will be expreſſed by the quotient of the latter divided by the former; and this I call the rarefaction produced in the cyl^r *per ſe:* now one of theſe cavities is $\frac{1}{4}$th, and the other $\frac{1}{8}$th of an inch in diameter; the depth of both being $\frac{1}{8}$th of an inch; ſo the ſum of their contents is about $\frac{9}{1000}$ths of a cubic inch: alſo the content of the cyl^r, which is about $13\frac{1}{2}$ inches long under the piſton, and two inches in diameter, is nearly 42,4 cubic inches; the quotient of which, divided by the former, is 4711: and this No. expreſſes the rarefaction in the cyl^r, and what ought to be produced in the rec^r by this pump, if it were even open at the top (in which ſtate it would in fact be the ſame as Mr. Boyle's original one) but as the piſton can hardly be made ſo exactly to fit and fill the bottom, as not to leave a farther vacuity under it, perhaps equal to $\frac{1}{3}$ of that of the cavities under the plate, ſo this rarefaction ſhould be reduced $\frac{1}{3}$, viz. to 3530; and if the performance of the inſtrument depended only on its mechaniſm, it would not fail of rarefying the air to this degree, every part being made perfectly air-tight.

Accordingly

Accordingly this pump in this ſtate (i. e. the valve being taken off) will ſo exhauſt a recr as to make the mercy in an open tube connected with it riſe as high as and ſometimes higher than that in a baromr of equal bore, placed parallel to it in the ſame ciſtern, and filled with mercy as carefully as it could be without boiling it in the tube; while the mercy ſinks in the mean time in the gage to the level of the external mercy and even beneath it; and the pear-gage, in the drieſt ſtate of the air and recr (in which condition only of the atmoſphere ſo great rarefaction could be effected) will then indicate a rarefaction of between 2000 and 3000. Such limited performance was nearly what this theory promiſed; and I alſo found the reſidual air under the piſton, to elevate the mercy in the gage ſo much at every ſtroke, when, on turning the key, it was let into a ſmall gage-veſſel (no recr being uſed) that it was plainly neceſſary to leſſen the reſiduum of air under the piſton, by applying the circulating-pipe, to tranſlate the air from the ſpace under to that above the piſton; by which the uſe of a valve, either in this or in the bottom of the barrel, was avoided; and at the ſame time, the top of the pump could be covered with a plate and valve, in order to take off the great weight of the air incumbent on the piſton, which makes the exhauſtion by a ſingle barrel (and ſo wide a one) too laborious.

The effect produced by this addition is, that whatever before was the reſidual air under the piſton, is now diminiſhed to ſuch a part

a part of the natural air contained in the circulating-pipe, as the cavities under the piſton are of the content of the whole cyl^r, i. e. as above ſhewn, to about the 3530th part. Now the croſs ſection of the channel of the circulating pipe, which is ſquare, is only $\frac{1}{10}$th of an inch, and its length 21 inches; its contents are therefore $\frac{21}{100}$th parts of a cubic inch; of the air in which, only the 3530th part is contained in the cavities under the piſton; i. e. nearly the 16809th part of one cubic inch, or the 712700th part of 42,4 inches (the content of the cyl^r) which N^o. will therefore expreſs the meaſure of air left under the piſton, and conſequently the rarefaction in the cyl^r.

This will be eaſily conceived, if it be conſidered, that when the piſton has been raiſed to the top, the valve muſt at that inſtant be open, diſcharging the laſt of the air pumped out of the rec^r; the circulating pipe as far as the key, will therefore be filled with common air; but when by turning the key of the cock, this pipe is opened into the rarefied air or vacuum under the piſton, the parts of the cyl^r, both over and under the piſton, are one vacuum connected by this pipe; and then the valve, not preſſed underneath, muſt ſhut, and no air enters above the deſcending piſton, but that which expands itſelf out of the circulating pipe; ſo that there is no air in the whole cyl^r, over or under the piſton, but what had been contained

tained in the pipe, and is now uniformly diffuſed through the cyl^{r}: and as both the orifices of the pipe open into the cyl^{r} during the deſcent of the piſton, ſo when this is at the bottom, the whole of this air is *over* the piſton, except ſuch a part of it as is expreſſed by the ratio of the content of the cavities under the piſton to that of the cyl^{r}.

It has been ſhewn, that when the pump was open at the top, and the circulating-pipe conſequently uſeleſs, ſo that the air above and beneath the piſton was of the *natural* denſity; yet in this ſtate, the rarefaction was as the capacity of the cyl^{r} to that of the cavities under the piſton; but as the air is rarer or denſer in the cyl^{r}, it muſt be ſo alſo in the cavities: and it will by the addition of the circulating-pipe and valve, be rarer in both theſe, in the proportion of the capacity of the cyl^{r} to that of the circulating-pipe (for the air in the latter being diffuſed in the cyl^{r} will be rarer or denſer there, as the cyl^{r} is larger or ſmaller;) ſo that the rarefaction now will be in a ratio compounded of the ratio of the content of the cyl^{r}, to that of the cavities under the piſton, and of the ratio of the content of the cyl^{r} to that of the circulating-pipe: for the reſidual air under the piſton is inverſely in this compound ratio, and the rarefaction is inverſely as ſuch reſiduum.

However ſince either the valve, or cover of the pump, or the collar of the piſton, will always admit ſome air, as the

piſton deſcends, frequently (in my trials) ſo much as the 50th part of the whole capacity of the cyl^r, the contents of the circulating-pipe of air muſt be ſuppoſed as encreaſed to that quantity; and the ſecond ratio above mentioned, of the cyl^r to the pipe, muſt be taken as that of the cyl^r to the 50th part of its own capacity; and according to this, the utmoſt rarefaction which could even by this theory be produced, would be about 176500 times; and this the pump would produce, ſuppoſing the piſton to throw up all the air above it, and no external air to intrude unleſs ſome other principle operated to prevent it. Alas! it falls far ſhort of this perfection; and as I have never found any reaſon to ſuſpect, that the piſton left air behind it adhering to the cyl^r, nor that any intruded by cocks or joints, in ſuch quantity as to occaſion ſo ſad a defect in its performance (but the contrary as will appear hereafter) this defect cannot, as I conceive, ariſe from the mechaniſm of the pump, but from other cauſes.

It is well known how much any moiſture, or any ſubſtance capable of generating a ſupply of aeriform fluids, either permanently elaſtic under the ordinary preſſure of the atmoſphere, or ſuch only in vacuo, will prevent exhauſtion, and occaſion a contradiction in the gages, by which its degree is indicated. I have conſidered and tried their various effects, having three gages applied to the pump together, viz. a common ſtrait barom^r-tube, in which the merc^y aſcended, the reduced barom^r-tube,

tube, in which it deſcended, and Mr. Smeaton's pear-gage accurately graduated; aud when I knew there was none of the above-mentioned cauſes to create the great and ſurpriſing variations, which at different times occurred in the pump's exhauſting power, even when the gages agreed ſo far that when any one of them indicated a greater or leſſer rarefaction, the two others did ſo likewiſe; I was led to look for the cauſes of theſe variations, either in the materials of which the pump, &c. conſiſted, or in the different qualities in the external air, which was in the recr; and to ſuſpect, that new and permanently elaſtic air is ſometimes generated *within* the pump, in the working, and ſometimes abſorbed or fixed again; and that the quantity of air ſo generated, is in certain ſtates of the atmoſphere and of the pump, ſo great, even in a ſingle ſtroke, as would fill with this factitious air, reduced to the denſity of atmoſpheric air, a ſpace even greater than that of the vacuities under the piſton, and of conſequence to limit the exhauſtion of the recr even within what the pump may be ſuppoſed to effect, without the addition of the valve and circulating-pipe. Now if ſuch production of air can be proved to exiſt, the theory here laid down, may be ſo far juſt, as the ſtructure of the pump is concerned, and defective only with reſpect to other principles.

In fourteen ſeveral trials of exhauſtion which I made in the months of July, Auguſt and September laſt (1795) the air being

 generally

generally very *dry*, the rarefaction produced, as ſhewn by the pear-gage, was, five times, between 3000 and 4000, the mercʸ in the baromʳ-gage ſtanding at the ſame times always above $\frac{1}{70}$th part of an inch higher than it ſtood in a ſtandard baromʳ of a wider bore, which was filled with mercʸ made very hot, as was alſo the tube *, as well as I could fill it without boiling the mercʸ in the tube; and the mercʸ in the reduced baromʳ-gage, ſunk below the level of the ſurrounding mercʸ. In the other nine trials, the rarefaction as ſhewn by the pear-gage was from 9000 to 26000; when the mercʸ in the baromʳ-gage ſtood at $\frac{2}{70}\frac{5}{00}$ths of an inch higher than that in the ſtandard baromʳ, and ſunk in the reduced baromʳ ſtill lower than before beneath the ſtagnant mercʸ. In ſeveral trials made from the 15th of September following to the 5th of December, when the air was always *moiſt*, I could not raiſe the mercʸ in the baromʳ-gage to the height of that in the ſtandard baromʳ (which ſtood cloſe beſide and parallel to it in the ſame ciſtern) except once, and never ſo high even in the pear-gage as it ſtood in moſt of the former trials: whence it is evident, from the correſpondence between the three gages, that a moiſt atmoſphere prevents the exhauſtion, not only of aqueous

* The tube was placed in a heated gun-barrel, and filled with the mercʸ heated on ſand, when filled, it was taken out of the gun-barrel, and being ſo cold, as juſt not to burn my gloves, an air-bubble was moved through it; and the mercʸ, as I found by trials, ſtood higher than it ever would do if poured cold into the ſame tube.

ous vapours, but even of permanently elaſtic air from the recr, contrary to what has been generally imagined, viz. that ſuch aqueous vapours would encreaſe the rarefaction as ſhewn by the pear-gage, in the ſame degree as they would diminiſh it, according to the teſtimony of the baromr-gage.

The reaſon why mere moiſture in the recr cannot be pumped out, though it be in the form of elaſtic vapour, when the air is moiſt (for in dry weather it actually can, by long working, as I have often found) I take to be this, that when it is got above the piſton, as ſoon as the valve opens, the preſſure of the external air inſtantly reduces the vapour to water, which ſubſides in a dew on the top of the piſton, and the upper parts of the pump (the little air which gets in through the valve, and by ſuppoſition moiſt, being inſufficient to dry it up) and reſolves into vapour again, when it can paſs by the circulating-pipe, opened below, into the vacuum under the piſton: Thus I ſuppoſe it is kept circulating within the barrel and cannot be diſcharged. But why any permanently elaſtic fluid in the recr could not, in damp weather, be exhauſted, as it was when the air was dry, is a queſtion of great difficulty. I had long before ſuſpected that air was produced within the pump, notwithſtanding its excellent performance juſt mentioned; of the reality of which, from the agreement of the gages, and chiefly from the electrical phænomena (to be hereafter recited) I could not

ſee

ſee the leaſt ground for doubt; and am perſuaded, that ſuch factitious air is generated more copiouſly, by the moiſture, or ſome quality in the atmoſpheric air in the recr, in damp weather, than when the air is dry.

An opinion or rule given without a reaſon, reſts only on the authority of the dictator: that this may not reſt on mine, I muſt beg leave to relate on what it is founded; for the fact, if it be one, is of the laſt conſequence to the perfection of the machine, as indicating a new principle, with reſpect to which it ought to be conſtructed. I muſt premiſe, that in making the following obſervations I uſed no other recr than a ſmall glaſs veſſel, covering a reduced baromr-gage, whoſe capacity, together with that of the ducts of the recr (which conſtitute a part of the contents of every veſſel to be exhauſted) was only about eight cubic inches; for the ſmaller the recipient is, the greater and more diſtinguiſhable by the eye, will be the aſcent or deſcent of the mercy in the gage, on the addition or ſubtraction of a given quantity of air. The mercy in the gage being by exhauſtion brought down within one inch of the level of that in the ciſtern, which was always done, the following effects were produced in working the pump; which I noted a great many times to have happened invariably.

1ſt, When

1ſt, When the piſton was ſeveral times raiſed to the top, and depreſſed again without turning the cock; the recr-pipe being conſtantly kept open; at every ſuch elevation or ſtroke, the mercy roſe a little in the gage; and generally in ſix ſtrokes about $\frac{1}{7}$th of an inch. In theſe circumſtances, ſome air remaining in the recr, was at each ſtroke, drawn into the barrel, as the piſton roſe, and returned again when it was depreſſed.

2dly, When the recr-duct and circulating-duct were cloſed by a half turn of the key, the piſton being previouſly put down, and the ſame number of ſtrokes were repeated, then on opening the communication with the gage, after depreſſing the piſton, the mercy did not riſe nor fall in the gage; but when, after the communication with the gage was open, the piſton was once more raiſed and depreſſed, the mercy roſe much more than it did at *any other* ſingle ſtroke, made when the recr-pipe was open. In theſe circumſtances there was no air in the barrel, during the motion of the piſton, except in the laſt ſtroke, by which alone the mercy was raiſed.

3dly, When the mercy was at the *ſtated* height in the gage, before the piſton was raiſed from the bottom, if it was elevated a part of its ſtroke, before the recr and circulating-pipes were ſtopt, by which means a part of the rarefied air in the gage-recr was drawn into the barrel, and impriſoned there on ſtopping the ducts, then, after the piſton had been raiſed and depreſſed

depreſſed the ſame number of times as before, and the communication of the barrel and gage was opened, the mercy was *always* found to ſtand lower than it did at firſt before the piſton had been worked; ſhewing, as it ſhould ſeem, that there had been an actual fixation or abſorption of air; but when another elevation of the piſton had been made, the recr-pipe being open, then the mercy ſtood much higher than at firſt; as if the air abſorbed, had been regenerated with increaſe; or as if by the working when the barrel had been cloſed, the ingredients for new air had been preparing in it, when a little air from the recr ſhould be admitted into it, as a generative ferment.

In all theſe circumſtances there was no communication between the external air and that under the piſton or in the recr; and the appearances took place uniformly and repeatedly; and the experiments were all repeated together on different days, with long intervals, and ſometimes in a reverſed order: ſo that whatever may have been the cauſe of the phænomena, it could not have been the irruption of any air; this could never produce theſe *regular* effects; it could only intrude by the piſton; in which caſe it would not always be the ſame in quantity, but it would always make the mercy *aſcend* in the gage; whereas in the ſecond caſe juſt mentioned, it did not; and in the third caſe, it always ſunk in it: moreover as the top of the barrel was in all theſe caſes open (the valve having been

been taken off) and the air preſſed with its whole weight on the top of the piſton, it would be moſt likely to force an entrance by this, when there was the moſt perfect vacuum under it, as in the ſecond caſe; whereas then the mercy never roſe in the gage, which proved that no air had got under the piſton: and in the other caſes, ſince the gage-recr was ſo ſmall in proportion to the barrel, and the air in it was thirty times rarefied before the piſton was raiſed, and above one hundred and fifty times after it was raiſed to the top, it muſt have been always ſo rare under the piſton as to have favoured the irruption of the air incumbent on it: and if air had been admitted any where but by the piſton or cock, its quantity admitted would be always the ſame in a given time, which would contradict the appearances that took place; however the changes in the gage were computed from the altitude at which it ſtood juſt before the variation.

And if it ſhould occur, that the aſcent of the mercy in the gage, was cauſed by external air adhering to the ſides of the barrel, and entangled in the oil or ointment there, which was expoſed to the air when the piſton was put down; a part of which air, not brought up by the aſcending piſton as being enveloped in the oil, yet would expand itſelf into the vacuum under the piſton, and remain there until a paſſage was opened for it into the recr; we ſhall find this will not agree with the

appearances; for if this circumſtance took place at all, it would do ſo equally in every ſtroke and in all the caſes mentioned; whereas it happened only in the firſt caſe; in the ſecond it did not; and in the third the contrary effect occurred. Moreover, the ſame phænomena were exhibited, when the pump was covered by the valve, and none but greatly rarefied air was over the piſton. It muſt be remembered, that all the air which once got under the piſton, muſt always have remained there until it paſſed into the rec^{r}; and would, if it had been produced as by this ſuppoſition, accumulate in every ſtroke. Neither was this ſurreptitious air owing to the foulneſs of the barrel, it being both foul and equally ſo in the circumſtances in which this air raiſed the merc^{y} in the gage; in thoſe in which it did not, and in thoſe in which the merc^{y} ſunk in it; and after the barrel was cleaned, the effects were the ſame as before.

It ſeems therefore, on the view of theſe facts, to be a neceſſary concluſion, that the cauſe of the phænomena, is to be looked for in the barrel itſelf, and in this, from the effect produced by the *motion of the piſton*; which effect was declared by the gage to be ſometimes a production of air *de novo*, and ſometimes an extinction or abſorption of it again.

To underſtand theſe effects, let it be conſidered, that though the pump barrel be perfectly clean, and the piſton leathers be even

even new, and lubricated with the cleaneſt oil, yet by a ſingle ſtroke, the oil will be tinged of a greeniſh colour from its having corroded or diſſolved a portion of the braſs. Braſs is a compoſition of copper and zinc, either of which, being diſſolved by the vitriolic acid, emits inflammable air; and diſſolved by the aerial or vegetable acid, will (I ſuppoſe) produce ſome kind of permanently elaſtic air; here ſuch ſolution of the braſs is manifeſt, and why, at every ſtroke of the piſton, air ſhould be generated; and alſo why I have often found more of this air to be produced in the pump (and the degree of rarefaction it could effect to be leſs) when it was clean than when dirty; as the oil being, when foul, more ſaturated, could diſſolve leſs of the braſs; and alſo that oil proved a worſe ſubſtance to lubricate the piſton than hog's-lard, becauſe (as I apprehend) the fluidity of the oil allowed every particle of it ſucceſſively, to come in contact with the barrel, and to diſſolve more of the metal; which could in a leſs degree happen with the lard, from its ſtiffneſs; neither is it hard to conceive that the ſolution of the metal, and conſequently the quantity of factitious air produced by it, ſhould be more copious in a moiſt atmoſphere than in a dry one; when it is conſidered that *ſales non agunt niſi ſoluti;* and that all metals are in damp weather moſt apt to tarniſh and contract ruſt, which is a ſuperficial ſolution of them. I believe alſo that air made moiſt not by what is called veſicular, but by diſſolved vapour (in which latter ſtate I found it to be

moſt detrimental to the pump's performance) is more impregnated with an acid principle; unleſs we may ſuppoſe that mere water diſſolves other metals as well as iron: And this with what has preceded, will perhaps account for the different powers of the machine in different ſtates of the air; and for its general failure in the perfection to be expected from the foregoing theory *.

THE

* The lower plate of the piſton was made of iron; and water or moiſt vapour will diſſolve or decompoſe iron; by which ſolution inflammable air is always emitted: whether this might have taken place in the preſent inſtance I know not, nor whether mere moiſture in the air, free from any acid, could act on the braſs as on iron, when aſſiſted by friction, or could diſpoſe the oil or ointment to act on it, and to produce by a kind of calcination any decompoſition of either the oil, or metal or water: what is certain is, that air is generated in greater quantity by ſome ſuch decompoſition in damp weather, than it is when the air is dry, and this both in ſummer and winter. We are told that iron, without heat, and zinc, charcoal and oils, with heat, will decompoſe water, and ſeparate inflammable air. Could the *friction* of the piſton produce the requiſite heat? we are alſo told that if water were decompoſed into its conſtituent parts, viz. inflammable air and dephlogiſticated air, this latter is or contains an acid principle, which, when uncombined with any other ſubſtance, would act on moſt metals; and ſo the damp air loaded with moiſture only, and not with any adventitious acid in the atmoſphere, may be conceived to produce effects different from thoſe of dry air. The paſſage of the electric matter however, in the atmoſphere, will convert a part of the air into nitrous acid, which diſſolves moſt metals; may not this abound more in the air in moiſt weather; moiſture in the air being generally, if not always, the effect or conſequence of electricity? and may not this be the cauſe of the ruſting of metals by damp air, and of the above-mentioned effects in the pump-barrel? This I believe to be the caſe, becauſe I found that in certain ſtates of the air, much aqueous vapour was introduced by it into the rec[r] without generating any conſiderable quantity of fluid which was permanently elaſtic, and becauſe the diſpoſition of iron, &c. to ruſt is not always the ſame when the moiſture and temperature of the air is the ſame.

The difficulty is, to account for the non-production of air in the ſecond caſe above-mentioned, and for its apparent extinction in the third. As to the former, there was indeed then almoſt no air nor humidity in the barrel, and it was ſeparated from whatever might be in the little recr; and though there was oil, yet I found by the ointment put upon the cocks, which was ever moſt and ſooneſt turned green in colour near the ducts and outer edges where the air had acceſs to it, than in the other parts, where it had not, that air was neceſſary to make the oil act on the metal; (nay, perhaps it is not the acid in the oil, but in the air, which is the ſolvent;) whence in this caſe, as there was no air in the barrel, ſo there was no ſuch action on the braſs of it. As to the phænomena in the third caſe, in which I evidently perceived a diminution of air, though I cannot explain it, being ignorant of the chymical analyſis of elaſtic fluids, and of thoſe combinations of airs, which occaſion ſuch diminution, and what might be the effect of the friction of the piſton in this caſe, from which reſulted all the phænomena; yet what I have ſtated will, as I think, authorize me to ſay, that the perfection of the air-pump does not depend only on its mechaniſm, but alſo on the materials of which it is made, and that thoſe materials are the beſt, on which the oleaginous and aerial acid has leaſt action. Accordingly the pewter-metal pump, which I firſt made, though inferior in the ſize of the barrel, which was a great diſadvantage, yet performed

better

better than the braſs one here deſcribed, until I added to the latter the circulating-pipe, which gave it the ſuperiority: but pewter, though beſt to reſiſt the action of the oil, being too ſoft; the barrel, if made of braſs, ſhould be tinned in the inſide, in the manner before deſcribed, which will ſomewhat improve it (and perhaps ſubſtantial gilding would be ſtill better:) but if one were made of glaſs, and encloſed in a metal caſe with cement; I think it could be eaſily ground and poliſhed, and a piſton previouſly formed to fit it, in a metal hollow cylinder or ring of equal bore: ſuch a piſton, having its top and bottom plates tinned in the common manner, would I believe conſtitute a better pump than any ever yet made, and procure more credit to the theory here laid down.

In that theory I have aſſumed, that the degree of rarefaction, which can be effected, will depend on that which the pump is capable of making under the piſton, without regard to the ſize of the rec^{r}; and as this is not at all the caſe with reſpect to air admitted in the working, from the pump's being leaky, which it ever is in a greater or leſſer degree; and an objection may therefore ariſe from the conſideration that on opening the communication between the cyl^{r} and rec^{r} at every ſtroke, any unextracted air under the piſton, and any otherwiſe intruded, will be together diffuſed in the rec^{r} and cyl^{r}; from whence it may ſeem, no difference of effect could ariſe from

theſe

theſe, which differ only in the manner of admiſſion: to illuſtrate this, and to enable the *experimenter* as well as the artiſt, to determine whether his pump is imperfect from its ſtructure or from accident; and how far it ought to be ſo from either cauſe; it is neceſſary, though I have (reluctantly) been ſo diffuſe in this account already, to ſtate the following particulars:

If air be conſtantly and uniformly admitted into the rec^{r} from this or the machine's not being air-tight, the degree of rarefaction produced by its final action, will depend on the proportion between the capacities of the rec^{r} and cyl^{r}; for there will always be a reſiduum as air is always intruding, and in addition to former reſiduums, will be the air admitted in each ſucceſſive ſtroke: in this caſe, the leſs the rec^{r} is, the more perfect will be the vacuum formed *. Suppoſe the rec^{r} and cyl^{r} to be equal, and the vacuum made in the latter *per ſe* perfect; then half the admitted air will be at length pumped out at every ſtroke let the quantity admitted be what it will: for

* Hence it is not the faireſt trial of a pump, to uſe a *very* ſmall rec^{r}, or to exhauſt the gage-tube inſtead of a rec^{r}; and it would be the more fallacious, if the reſiduum of air under the piſton, might be variable in different ſtrokes, from the defective and uncertain performance of valves or of any thing of valve-like ſtructure; for as one ſtroke with a large cyl^{r} will nearly exhauſt a tube; ſo a lucky ſtroke or two among many, in which the valves perform their office, will ſhew a rarefaction, which might not be produced, where many were requiſite to exhauſt a larger rec^{r}.

for inſtance, if in the time of each ſtroke, a cubic inch of air intrudes, and the contents of the rec^{r} and cyl^{r} be fifty cubic inches each; then the reſiduum in the rec^{r} after the firſt ſtroke, would be $\frac{1}{2}$ an inch; to which would be added one cubic inch next admitted; and by the ſubſequent ſtroke, half the ſum of theſe would be extracted; i. e. the half of $1\frac{1}{2}$ inches (or $\frac{3}{4}$ of an inch) which the next addition would encreaſe to $1\frac{3}{4}$: ſo that ſuppoſing the rec^{r} at firſt empty, yet ſome would accumulate in every ſtroke, until the reſiduum would be equal to that intruding during one ſtroke, viz. until both would be equal to two inches; after which one inch would intrude, and one be extracted at every ſtroke: ſo that the air in the rec^{r} could never be rarefied beyond fifty times, nor finally leſs than to that degree.

And if the cyl^{r} were twice as large as the rec^{r} with its ducts; the rec^{r} remaining as before; and the ſame quantity (one cubic inch) admitted at each ſtroke; then almoſt $\frac{1}{2}$ of this would be drawn into the cyl^{r} by the laſt ſtroke, and $\frac{1}{2}$ remain in the rec^{r}, when the piſton was raiſed to the top; ſo that now the greateſt rarefaction would be doubled, and equal to one hundred, which, when the rec^{r} and cyl^{r} were equal was fifty.

And univerſally, as the capacity of the cyl^{r} is to that of the rec^{r}, ſo is the whole intruded air during one ſtroke, to the laſt

laſt reſidual air; ſo that the *leſs the recr is*, the leſs will be the reſiduum, and conſequently the *greater the rarefaction:* but this is after the pump has exhauſted as much as it can; for in every ſtroke from the commencement to the end, the air in the recr, whether left in it, or intruded, (or its denſity which is the ſame thing) is to that which remains in it after any ſtroke (or its then denſity) as the ſpace into which it is diffuſed on the elevation of the piſton, i. e. the aggregate or ſum of the capacities of the recr and cylr, is to the primitive ſpace in which it was confined, i. e. to the capacity of the recr alone: In which analogy, each of the conſequents, divided by its reſpective antecedent, muſt give the ſame quotient, or ratio, and vice verſa; and ſuch quotients muſt be *in every ſtroke conſtant quantities*, becauſe the two laſt terms of the analogy are ſuch: but the reſidual air after any ſtroke is the primitive air with reſpect to the ſubſequent ſtroke, hence if the firſt reſidual be $\frac{1}{2}$ of the primitive air, the ſecond will be the $\frac{1}{2}$ of $\frac{1}{2}$ (i. e. $\frac{1}{4}$) and the third, $\frac{1}{2}$ of $\frac{1}{2}$ of $\frac{1}{2}$ (i. e. $\frac{1}{8}$) of the primitive air; and any reſidual will be the laſt term of a geometrical progreſſion, the No. of whoſe terms is the No. of ſtrokes; each term being ſo often involved or multiplied into itſelf: if the firſt term be as here, the quotient of the recr divided by the ſum of the capacities of the recr and cylr, it will expreſs what fractional *part* of the primitive air the next reſidual is; and the progreſſion or ſeries will be fractions and *decreaſing;* and if the firſt term of the ſeries be the quotient

of the aggregate of the recr and cylr divided by the recr, this quotient will be a whole or mixed No. expreſſing the *No. of times* the primitive air contains the reſidual, i. e. expreſſing the rarefaction; and it will be the common term of a ſeries reciprocal of the former one and *encreaſing*; the value of correſponding terms in each, being equally above and below unity. This is the common theorem for determining the rarefaction after any No. of ſtrokes *; but it ſuppoſes a perfect vacuum

* By this theorem two things will eaſily be found, which the experimenter muſt know, viz. what is the rarefaction which ought to be produced by any Nr of ſtrokes, and, and what Nr of ſtrokes are requiſite to produce a certain degree of rarefaction; (for I have found that if the pump does not effect this in a very few more ſtrokes than the theory requires, it will generally be loſt labour to continue to work it, unleſs in dry weather or a dry room, one has hopes of pumping moiſture out of the recr). Both particulars may be beſt found by the aſcending ſeries; viz. by multiplying the quotient, of the ſum of the contents of the recr and cylr (in cubical inches) divided by that of the recr (which will be a whole or mixed Nr, the fractional part of which latter, is to be reduced to a decimal) continually into itſelf, as many times as there are ſtrokes, and throwing away from every product all the decimal figures to the right hand, except two or three, which will occaſion no material error, and much abridge the work; which is alſo farther abridged by multiplying any power, ſo produced, by itſelf, or by any other power thus before found; for the product thus ariſing, will be that power whoſe exponent is the *ſum* of thoſe ſo multiplied; as the cube or third power drawn into itſelf produces the ſixth power; or drawn into the fifth power, produces the eighth power; and ſo in any other. Thus the rarefaction produced by any Nr of ſtrokes will be found, being expreſſed by that product or power, whoſe exponent is the Nr of ſtrokes; and it will alſo be ſeen in the proceſs, what Nr of ſtrokes ſhould produce any given degree of rarefaction; which may alſo be found by the converſe of this proceſs, viz. by *dividing* any greater power found, by any leſſer, for the quotient will be that power whoſe exponent is the *difference*

vacuum to be made under the elevated piſton, and that no external air intrudes; ſo that when either of theſe takes place, the

difference of their exponents. But when the rec^{r} is large, and many ſtrokes will be requiſite to exhauſt it; the operator who muſt calulate what ſhould be the power of his machine, may avail himſelf of the help provided for him by the noble inventor of the table of logarithms: for as in theſe the ſum or difference of any two logar^{s} is the log^{m} of the product or quotient of the correſponding natural N^{rs}; and that the product or quotient of a log^{m} (multiplied or divided by any N^{r}) is the log^{m} of that power or root of the correſponding natural N^{r}, whoſe exponent is the multiplicator or diviſor of the log^{m}: ſo whatever is effected by multiplication, diviſion, involution or evolution of natural N^{rs}, may be performed by addition, ſubtraction, multiplication and diviſion of their log^{s}. And thus the *quotient* above-mentioned may be found by *ſubtracting* the log^{m} of the rec^{r} from that of the aggregate of the rec^{r} and cyl^{r}, and then multiplying the remainder by the N^{r} of ſtrokes of the piſton; for the product will be the log^{m} of that N^{r} which expreſſes the rarefaction; alſo to find what N^{r} of ſtrokes will produce any required rarefaction; take the log^{m} of the N^{r} expreſſing this rarefaction; it is plain from what has been ſaid, that this log^{m} muſt belong to that natural N^{r}, which is ſuch a power of the aforeſaid quotient as would be produced by the ſame N^{r} of involutions, as there ſhould be ſtrokes of the piſton employed to produce the rarefaction; and that if this log^{m} were evolved as many times as we muſt ſuppoſe its root to have been involved; that root would be found which belongs to the original quotient by whoſe involution it was produced; and that if the log^{m} of the power be divided by the log^{m} of the root, the quotient will be (from the nature of log^{ms}) the N^{r} expreſſing how often it had been involved: there is nothing then to be done ſince we know the log^{m} of the above-mentioned quotient, which is the root, but to divide by it the log^{m} of the deſigned rarefaction, and the quotient will be the N^{r} of ſtrokes of the piſton required.

I inſert this and many other things for the eaſe of thoſe who may be more converſant in experimental chemiſtry than calculation, and to enable ſuch (without recurring to other books) to ſubject the air-pump to a rigorous trial; theſe will alſo be the perſons moſt likely to make the beſt uſe of this machine, on which account

the unextracted and intruded air, muſt be in every ſtroke added to the reſidual air in the recr, as a conſtant quantity; which will

and to prevent the fault of the artiſt from being attributed to the ſtructure of the inſtrument, I ſhall alſo beg leave to add what follows:

The quantity of air in meaſure, that may in any length of time have forced an entrance into the recr, may be found, and the juſt allowance made for it in the defect of the pump's performance, by ſtating, as the height of the mercy in the ſtandard baromr, is to its aſcent or deſcent in the reduced or ſtandard baromr gages, in a given time, ſuppoſe ſix hours, ſo is the whole content of the recr and its ducts, to the part thereof which would be filled in ſix hours with the intruded air, if reduced to the denſity of atmoſpheric air. Alſo, to know what allowance is to be made for ſuch intruſion in the defective altitude of the mercy in the gages, ſtate, as ſix hours, is to the time in which one ſtroke is made (ſuppoſe half a minute) ſo is the aſcent or deſcent of the mercy in the reduced and ſtandard baromr-gages, in ſix hours; to the aſcent and deſcent which ought to be occaſioned by the air intruded, in the time of one ſtroke; then the aſcent and deſcent thus found, being diminiſhed or increaſed according to the ratio of the recr to the cylr, and deducted from and added to the altitude of the mercy in theſe different gages, any remaining difference between that altitude, and what exiſts at the time in the moſt perfectly filled ſtandard or reduced baromr, is to be attributed to the imperfection of the machine.

If the altitude of the baromr-gage, be referred to that of a ſtandard-baromr filled with mercy not boiled in the tube, though it were otherwiſe poured hot into it, the tube itſelf being hot, and carfully purged of air by moving an air-bubble through it, the mercy and tube being perfectly clean, yet the altitude of the mercy in *ſuch* a ſtandard-barmr muſt be ſuppoſed to be leſs than it would be if the tube were perfectly filled, by at leaſt $\frac{25}{1000}$th parts of an inch; becauſe as this air-pump never failed in a favourable ſtate of the air, to raiſe the mercy in the gage thus much higher than it ſtood in a ſtandard-baromr filled (ſeveral times) in the above manner; it is plain this latter will be always imperfectly filled and the height of the mercy in it deficient, by the above quantity, and I found that it would

will variouſly alter every term in theſe ſeries, and produce other ſeries, the terms of which will continually approximate to

would be ſtill more deficient if the mercy were poured cold into the tube. Now ſuppoſing the altitude of the mercy in the ſtandard to be thirty inches, $\frac{25}{1000}$ths of an inch is the 1200th part of the whole; and if the mercy in the gage be as high as that in the ſtandard, the rarefaction is only 1200; and that in the ordinary Torricellian tube, is, I believe, never greater, but moſt commonly leſs than this; though from there being no air bubble apparent at the top of ſuch a tube, when on inclining it the mercy aſcends, one might imagine that no claſtic fluid reſted above the mery: for if the tube be filled cold, there will be moiſture within it, which will be condenſed into ſmall inviſible particles by the preſſure of the atmoſphere when the tube is inclined, but will expand again in claſtic vapour, depreſſing the mercy, when by placing the tube vertical, that preſſure is removed: and when the tube is filled hot, and ſo has no moiſture in it, an air-bubble will in the ſame circumſtances be viſible. This I found however to be partly diſcharged, and the mercy to ſtand higher in it, by inclining the tube while in the ciſtern (after it had ſtood perpendicular and the mercy had ſunk to the natural altitude) until it had aſcended to the top, and taking it full out of the ciſtern, by cloſing its end while immerſed in it, with my finger, then having ſhaken out a drop of mercy to allow an air-bubble to be once moved through it, this brought up with it moſt part of the air which had been collected in one bubble at the top; after which reſtoring the drop which had been taken out, and immerging it again in the ciſtern, the mercy ſtood in it higher than before, and I believe from this management it would always do ſo. This was done in the preſence of Doctor Young, who from his well-known zeal for the advancement of ſcience, was pleaſed to be preſent at a trial of the pump's performance; at which time it ſo far exhauſted a rec as to raiſe the mercy in the baromr-gage, near $\frac{1}{10}$th of an inch higher than it ſtood at the higheſt, in the baromr-tube here mentioned, of equal bore with that of the gage, and ſtanding parallel and perpendicular together in the ſame ciſtern.

If there be in the recr no moiſture nor vapour expanſible only in vacuo, the pear-gage (as I have always found) will correſpond with both the baromr-gages; and when the rarefaction is near 4000, the eye cannot diſtinguiſh the difference between

to ſuch numerical part or multiple of the ſum of the ſurreptitious and unextracted air during one ſtroke, as is expreſſed in

tween the height of the mercʸ in the latter and that in the moſt perfect ſtandard-baromʳ; becauſe the difference in their altitudes is not the hundredth part of an inch; ſo that greater degrees of rarefaction can be known only by the pear-gage; which ſhould therefore be uſed; and it ſhould be of a proper form and accurately graduated. It is a glaſs-veſſel in ſhape ſomewhat like a pear or rather an hydrometer, with a bulb, of a ſize to contain between four and ſix ounces of mercʸ, terminating on either ſide in a tube: that below the bulb (about an inch in length) is open; the upper part or ſtem (about five or ſix inches long) is ſealed hermetically at top; the internal diameter of one half of the length of the ſtem next the bulb, ſhould be about $\frac{1}{20}$th of an inch, and the cavity exactly cylindrical, as likewiſe muſt be that of the upper half; but this latter ſhould be as narrow in the bore as a middle-ſized mercurial thermometer, viz. about $\frac{1}{100}$th of an inch in diameter: if the ſtem were of the ſame dimenſions throughout, it could not, unleſs made inconveniently long, meaſure both ſmall and great degrees of rarefaction: it is eaſily made of the above form, by blowing a bulb on a piece of glaſs-tube, about $\frac{1}{20}$th of an inch in diameter; then drawing out the upper part of it (by the glaſs-blower's lamp) into a ſlender tube, and ſealing its end: or rather by adding to the tube a piece of a thermometer tube. The ſtem is faſtened in a braſs pipe or caſe, having a wide ſlit along its whole length, through which the mercʸ in the ſtem is ſeen, and the degrees are marked on the caſe. During the exhauſtion, the gage is ſuſpended by a ſlip-wire with its open end over a ciſtern of mercʸ within the recʳ, ſo that the air in it is as much rarefied as that in the recʳ; and when the pump has been wrought as much as is thought proper, the end of the gage is immerged in the mercʸ, which on the *gradual* readmiſſion of the air, will be forced up into the gage, and fill the bulb; all the air which had been left in the gage, riſing to the top, and being reduced nearly to the denſity of the external air; which it would be exactly; if the gage were placed not vertical, but horizontal. Then, as the whole cavity of the gage, is to the part at the top filled only with air; ſo is the primitive air which was in the gage, and alſo in the recʳ, to the laſt reſiduum in each reſpectively, or ſo is the rarefaction produced; hence, the ratio of the whole content

in the deſcending ſeries by the ratio of the recr to the cylr, or the quotient of the former divided by the latter; and in the

tent of the gage to that of *any part* of the ſtem, muſt be known, and it is thus found.

Let the whole of the narrow part only of the ſtem be filled with mercy, and this carefully ſhaken out again, and weighed by the niceſt balance; let the ſame be again filled together with the wider part of the ſtem, as far as it is cylindrical, and the contents weighed as before; then let the whole veſſel be quite filled, and the weight of the mercy it holds be found: ſince the capacity of the whole gage is to that of the ſtem, or any part of it, as the quantities or the weights of mercy each contains; and the content of each half of the ſtem is thus known, and the ratio of the ſame to the whole, and ſince each half of the ſtem is in itſelf cylindrical, equal parts of the *length* of each ſeparate ſegment, will be equal portions of the *content* of that ſegment; i. e. the contents are as the lengths; but the contents, and therefore the lengths, will be inverſely as the rarefaction, when the reſidual air in the gage is contained within them; ſo that if the whole length be graduated from the upper end to the lower in any Nr of equal diviſions, and the rarefaction be known, when the mercy ſtands at the loweſt diviſion or greateſt Nr (which rarefaction is expreſſed by the quotient of the weight of the mercy filling the whole gage, divided by that contained in the whole ſegment) then, as the whole Nr of diviſions, is to that correſponding rarefaction, ſo is *inverſely* any other leſſer Nr of diviſions, to the rarefaction, when the mercy will ſtand at ſuch diviſion. This method muſt be taken to graduate each half of the ſtem ſeparately, as they are of different diameters; but in eſtimating the length of the wider half, as the content of the narrower half muſt be added to it, ſo the wider part muſt be computed to be ſo much longer than it is, as the addition of the content of the narrower part would make it, if this were reduced to the ſame diameter as that of the wider part.

But if the ſtem were to be thus graduated by an arbitrary Nr of diviſions marked on it, the rarefaction anſwering to each of them would be expreſſed by odd or broken Nrs unfit for meaſuring it; and it would be difficult, when the mercy ſtands not at any diviſion, but between two, to find what may be nearly the rarefaction in

the aſcending ſeries by the reciprocal of the ſame, or by the ratio of the cyl^r to the rec^r. For the air intruded, &c. at each ſtroke,

that experiment; it is therefore neceſſary to graduate the ſtem by a decimal diviſion, expreſſing the rarefaction or reſidual air by 100ths or 1000ths; which may be thus done:

Let, as above, the weight of the whole content of the gage be divided by that of the whole content of that ſegment of the ſtem, which is to be graduated; the quotient will expreſs the rarefaction when the mercy ſtands at the loweſt diviſion or end of the ſegment; then ſay, as that quotient or rarefaction, is to the whole length of the ſegment, meaſured by and expreſſed in equal parts, ſuppoſe hundredth parts of an inch; ſo is inverſely the decimal, centeſimal, or milleſimal N^r neareſt to and above the ſaid quotient, to the N^r of hundredth parts of an inch (to be meaſured from the top of the ſegment) at which the (loweſt) diviſion ſhould be marked on it, anſwering to ſuch decimal, centeſimal, &c. N^r expreſſing the rarefaction, when the mercy will ſtand at that diviſion: and as the ſaid quotient (of the weight of the content of the whole gage, by that of the whole ſegment) to the ſaid length of the ſegment; ſo is the ſecond decimal, centeſimal or milleſimal N^r inverſely, the ſecond diviſion to be marked; and ſo on until the whole is graduated.

Example. Let the weight of the mercy contained in the narrower or upper ſegment, be two grains, and that in the whole gage be 1970 grains (which were the meaſures of my gage): the quotient of the latter divided by the former is 985; ſo that when the mercy ſtood at the loweſt diviſion, the rarefaction was 985; the neareſt milleſimal N^r to which is 1000: alſo the length from the top of the ſtem which two grains weight of mercy filled, was 141 hundredth parts of an inch: as therefore 985 is to 141, ſo is inverſely 1000 to 138, 88 hundredth parts of an inch; which is the length from the top of the ſtem, at which the diviſion ſhould be made, where the mercy, when ſtationary, would ſhew a rarefaction of 1000. In like manner as 985 : 141 : : inverſely 2000 : 69, 44 hundredth parts of an inch, the length from the top, at which the diviſion anſwering to a rarefaction of 2000 ſhould be made; which will be half the former length: and thus may the reſt of the ſegment be graduated

ſtroke, being the ſame, its quantity muſt at length be directly as the rec^{r}; and the quantity remaining after each ſtroke, as the capacity of the rec^{r} to that of the cyl^{r}; conſequently the rarefaction the reciprocal of this.

Hence appears the miſchief of leaving any air under the depreſſed piſton; for the whole of it *muſt paſs into the rec^{r}* at every ſtroke; and if the rec^{r} be ſmall, the greater will be its denſity there; but if the rec^{r} be large, there muſt be more ſtrokes to exhauſt it, and ſo more additions to the reſidual air in it; alſo leſs of it can be pumped out again: however, though no air were left under the piſton, yet if air intruded from the machine's being leaky, its power in extracting ſuch ſurreptitious air, would not at all correſpond with the ſame in extracting the primitive air in the rec^{r}; for with reſpect to this latter, the greateſt rarefaction in the cyl^{r} itſelf is given,

graduated; firſt, either by a continual biſection of the diviſions towards the top (which will be always one extremity of the interval biſected) for ſuch biſection, as it *halves* each length of the ſegment, muſt *double* the rarefaction correſponding to the lower extremity of the portion biſected, theſe portions being inverſely as their correſponding rarefactions; and ſo the leaſt rarefaction (of 1000) would be continually doubled; or, ſecondly, according to the above-mentioned analogy, by dividing the product of the leaſt rarefaction, multiplied by the length of the ſegment (viz. in the above caſe of 985 by 141; or of 1000, by 138,88, which is the ſame) by any greater N^{rs} expreſſing ſuch rarefaction as one would chuſe to mark on the ſcale; for inſtance, by 1500, 2500, &c.: then the quotients will be the lengths from the top, at which theſe rarefactions ſhould be marked. The lower or wider ſegment of the ſtem is to be ſeparately graduated in the very ſame manner.

and ſo likewiſe muſt be ultimately that in the rec^r, let its capacity be what it may. In this machine, the air under the piſton being conveyed away by the circulating-pipe, before the communication of the cyl^r with the rec^r is opened, it cannot get into the rec^r, and the rarefaction in the cyl^r being as it were indefinitely great, equal as above-mentioned to 176000, that in the rec^r may be indefinitely encreaſed within this limit; whereas the intruded and unextracted air under the piſton (were there any) *would* get into the rec^r, and the part of it which could be pumped out, would depend on the proportion between the cyl^r and rec^r, juſt as in the caſe of air admitted through leaks in the machine.

It is not therefore here pretended, that the rarefaction could be carried to an unlimited degree, even on the principles of the pump's mechaniſm; and yet perhaps it may be preſumed that, even on theſe, its conſtruction is ſuperior even to that of Mr. Cuthbertſon, the only one which pretends to a power of indefinite exhauſtion: and as it is only from a belief of this, that the machine here deſcribed is publiſhed, ſo I may be permitted to obſerve, (having had no opportunity of aſcertaining by trial the excellence of his, though I believe it is excellent; nor of ſeeing any deſcription of it, but that in the Encyclopædia Britannica, juſt publiſhed here) that I conceive its perfection muſt depend on the ſuppoſed circumſtance of no

no air being ever admitted into the barrel through the valve or through the perforation in the piſton: for if when the valve is open, diſcharging the air pumped out, and the external air is then preſſing on the piſton with its whole weight, any of it ſhould force its way through the piſton; the recr is then open towards the barrel, and it muſt paſs in an incalculable quantity into the recr. Now the piſton in his pump has the duct through it opened at every ſtroke, and it is cloſed again by a conical ſtopple, ſupplying the place of a cock, and made air-tight only by oil; which ſtopple being faſtened cloſe in the piſton only by the force with which the piſton is raiſed, ariſing from friction, this force or preſſure (unleſs the piſton moves more ſtiffly than one lubricated with abundance of oil, may be ſuppoſed to do) may ſometimes be inſufficient to make the ſtopple firm in its ſocket, until it is gradually preſſed by air condenſed above it, and until the valve opens, and the external air reſts on the piſton; ſo that if the piſton be not perfectly air-faſt, ſome of it muſt get through into the recr; and though the friction of the piſton ſhould be *always* ſo great as to prevent this happening, yet if any ſmall particle of dirt ſhould have got between the ſtopple and its cavity, it would remain impacted there, and be likely to render the duct permeable to air: it ſeems therefore too delicate a circumſtance, to reſt the performance of the machine on, that this duct encloſed within the barrel, and opened at every ſtroke, ſhould, at once, be ſo cloſely ſhut

again, as never to admit air: alſo the baſe of the ſtopple muſt be broad, that it may be eaſily diſengaged from its cavity which enlarges the ſurface or joint that is to be made impervious to air: this ſtopple is in reality a kind of valve, reſting on the extent of its whole conical ſurface as a baſe, and it was before obſerved how difficult it is to make a valve air-tight, when the ſmalleſt ſolid particle of duſt, &c. will prevent the contact of the ſurfaces though ever ſo extenſive, and that the danger of this encreaſes with the enlargement of the ſurface; and that were it not from this natural imperfection of valves, Mr. Smeaton's air-pump ought to be inferior to none; its mode of action being preciſely the ſame as that of Mr. Cuthbertſon, except that in the latter, metallic valves or ſtopples are ſubſtituted for the flexible valves in the former: whereas the excellence of a ſtop-cock is, that the ſurfaces of the key and ſhell are never *ſeparated:* no dirt can get between them, nor oil be blown away; but ſtiff ointment may be applied inſtead of oil, to make them air-faſt: to the ſtop-cock therefore, and the unperforatated piſton, I attribute the excellence of the pump here deſcribed above others conſtituted on the like principle; for in it, though air ſhould get in through the upper valve, &c. it cannot get into the rec^{r}; whereas in the others, if air inſinuates through the piſton, it muſt do ſo; and if to prevent this, in Mr. Cuthbertſon's machine, it were provided to have a pool of oil above the piſton, I imagine

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it would not be a perfect remedy, even though I were miſtaken in the apprehenſion that ſuch abundance of oil, would generate a greater quantity of factitious air: for when the valve or duct in the piſton is open, the oil muſt deſcend through it with all the impurities that may be in it; and if the oil above the upper valve can deſcend into the barrel, the impurities in it will be added, which if they adhered to the ſtopple or valve in the piſton, would be likely to occaſion its admitting air; alſo the oil being thus churned in the barrel, would perhaps entangle air, eſpecially when viſcid, as it will become by corroding the braſs. In this pump, it is not neceſſary to uſe oil, eſpecially if the barrel be made of pewter; for then the hog's-lard or ointment uſed will not loſe its lubricity; in fact fluid oil is inadmiſſible, for it would certainly render the cock, though formed and ground with care (how much more then a valve?) not air-tight; the air forcing a paſſage even through the oil within the joint, if this be not very cloſe, which in a cock whoſe key is in continual motion cannot always be; nor is this hard to conceive; for where ever a column of merc^{y} as high as that in the barom^{r}, reſting over a joint or chaſm, could force a paſſage, the air will do the ſame, and perhaps more powerfully.

It will appear then that there is no kind of limitation in the pump here deſcribed, which is not in any other; for in the

the others, whatever air is left above the piſton undiſcharged, or enters by the valves in the piſton or top of the pump, is diffuſed in the cyl^{r} under the piſton (ſuppoſe it could not get into the rec^{r}); and the piſton being put down, whatever cavities are under it, have the ſame quantity of it reſting there, when the rec^{r} is opened, as in this pump; and if air inſinuates by the perforated piſton, it is an inconvenience from which this is ſecure; alſo it condenſes with a ſingle barrel, and without any additional parts, which none other can do. It might be conſtructed with two barrels, and the two cocks might be turned together by one handle, in a manner well known and in uſe; but in this form, it would neither be convenient nor portable; however in the form here deſcribed, the ſingle barrel may be made ſo large, as to exhauſt as faſt as two of uſual ſize; and it is eaſy to conceive from the theory, that the largeneſs of the barrel is every way an advantage, for the cavities under the piſton need not be proportionably enlarged.

As it is ſcarcely poſſible to prevent the intruſion of ſome air while the pump is working, and as the quantity ſo intruded, will be proportional to the time of exhauſting, which time would be injudiciouſly lengthened, if the pauſe at each ſtroke were made longer than is neceſſary for the air to paſs from the rec^{r} to the cyl^{r} until its denſity is the ſame in both in any degree of the rarefaction; it would be a deſirable thing

thing to know whether the air paſſes into the cyl^{r} with a velocity variable according to its denſity, and in what ratio. The time of the air's paſſage cannot be diſcovered by the motion of the merc^{y} in the gage; for when the air is much rarefied, this motion during one ſtroke, is ſo little as to be imperceptible, and when it is greater, the merc^{y} vibrates ſo much in the tube, and undulates ſo long, after the air is paſſed into the barrel, that the term of its paſſage cannot be diſcovered: it muſt be found by reaſoning on phyſical principles; and the enquiry is to be proſecuted on theſe data or aſſumptions, that the meaſures of the rec^{r}, duct and cyl^{r} are invariable quantities; and that in the cyl^{r} there is a perfect vacuum, into which the air in the rec^{r} is to expand itſelf, after the piſton is raiſed to the top.

The conſtruction of this machine was primarily undertaken with a view to diſcover whether the Aurora Borealis is an electrical phænomenon; whether we could in *large* exhauſted veſſels exhibit its genuine appearance; what muſt be the rarity of the air in which it is viſible, and the heights in the atmoſphere, wherein it exiſts, and within which it is (if at all) confined, &c. Theſe enquiries however I did not proſecute; yet the reader will not I hope be diſpleaſed at my extending this long paper ſtill farther by an account of the following experiments relative to them, though they are inconcluſive; eſpecially,

eſpecially, as from the difficulty of making a perfect vacuum in the ſtandard-barom^r, and of comparing the altitude of the merc^y which ought to be in it, with that in the gage, I found the exhibition of the genuine Aurora Borealis, the moſt certain mark of great rarefaction, as not requiring a compariſon of the barom^r and pear gages.

I CONNECTED with the rec^r (which was uſed in the foregoing trials of the pump's exhauſting power, and whoſe capacity was 122 cubic inches) by means of a braſs box fixed on the top of it, one end of a glaſs-tube twenty-one inches long and $\frac{1}{4}$ of an inch in diameter, furniſhed at one end with a braſs cap terminating in an open pipe, which was inſerted laterally into the box of the rec^r: the other end of the tube was cloſed ſometimes with a plate of braſs cemented on it, and at other times with a glaſs plate; both which afforded the ſame appearances. The tube was extended horizontally, being ſupported at the end remote from the rec^r by a glaſs-pillar; and it was exhauſted with the rec^r; during the proceſs of which, I applied to the tube in the dark, an electrified glaſs-tube, which produced the following appearances in repeated trials.

THE tube ſhewed no electricity from preſenting to it the excited tube, until the rarefaction was about 100; then there appeared within it denſe and bright coruſcations, but they were

were interrupted, not extending the whole length of the tube, neither would they appear when the excited tube was preſented to the end, but when to the middle only of the exhauſted one; and it was remarkable, that coruſcations exactly reſembling the above, in their form, &c. except that they appeared when the excited tube *touched any* part of the other one, and that they were ſo faint as to be ſcarce viſible in a room made quite dark, firſt *began* to appear, when the rarefaction, as ſhewn by the pear-gage, was 4000: the ſtandard-barom^{r} above-mentioned being, at the ſame time, at 30,1, and the barom^{r}-gage at 30,12. When the rarefaction was carried beyond this, ſo as to raiſe the merc^{y} in the barom^{r}-gage, a little higher in ſeveral trials, and to advance that ſhewn by the pear-gage ſometimes up to 26000, the appearances were the ſame, but the gleams of light ſtill fainter; they were a colourleſs pale white; the coruſcations, which were ſcarce viſible, *ſeemed* conical pointed, waving or ſtreaked, and did not extend the whole length of the tube, exhibiting the moſt perfect reſemblance of the thin pale coloured Aurora Borealis.

In the intermediate degrees of rarefaction, between 100, and 4000 (indicated as above by the *gages*) the phænomena were as follows:

At 300, the preſentation of the excited tube *near* to the exhauſted one, firſt occaſioned continued flaſhes in it, filling

its whole length; but this only when preſented to the middle, not the ends, this latter firſt occurred when the rarefaction was greater; and then at every approach and receſſion of the excited tube, without freſh excitation, even for fifty times together, and with ſcarce any diminution of brightneſs to the laſt, or ſign of decay until I ceaſed to preſent it, ſuch flaſhes were produced; they filled the whole tube, but that they were brighter and of ſmaller diameter at the middle of its length; they were alſo not only denſer but of a more yellow colour, than the faint coruſcations before deſcribed: but the moſt diſtinctive difference between both theſe kinds, and indicating the great degree of rarefaction neceſſary for the exhibition of the former was, that when *they* appeared, the excited tube produced no light at all in the other, except at the *firſt* preſentation and *actual contact* with it: from which I concluded (too ſtupidly and haſtily) that the electricity of the former was completely diſcharged, and that the more perfect vacuum, was a more perfect conductor of electricity, even more ſo than metals: but though I am yet of opinion that the fact was ſo, yet it may, for ought I know, be poſſible, that the tube produced no light after the firſt preſentation, not becauſe it was quite diſcharged, but becauſe its electricity, leſſened by the firſt diſcharge, would not paſs nor be conducted by the more perfect vacuum in the other tube; or, if it burns, deſtroys, or changes into nitrous acid the air which conducts it, what remained

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in the tube, &c. may by the firſt exploſion have been ſo conſumed.

But whether this or the contrary be the fact, the experiments have ſatisfied me, that the Aurora Borealis *is* an electrical phænomenon; that, (at leaſt when it is faint and of a pale colour) it cannot appear in air leſs rarefied than near 4000 times *; and conſequently that its neareſt diſtance from the earth is about forty-five miles (according to Doctor Halley's table of the air's rarefaction at different altitudes); that in air rarefied more than 26000 times, it would not be viſible, and therefore its greateſt diſtance is about fifty miles, (by the ſame table): I am notwithſtanding ſenſible it may be leſs or greater: it may be *leſs*, for though my pear-gage ſhewed that degree of rarefaction, I pretend not to ſay what the rarefaction really was; it might be ſix times leſs; but it could not, I think, be known by any gage, what it was, as I am perſuaded, that the difference of altitude between my barom^r-gage, and that of the moſt perfect barom^r, would at that time be imperceptible to the eye: it may be *greater*, for a quantity or ſtratum of electric matter $\frac{3}{4}$ of an inch in thickneſs, as in my tube, may be inviſible, when one of the ſame denſity, but many

 miles

* Perhaps becauſe denſer air, affording too much reſiſtance to its paſſage, i. e. being a worſe conductor, it takes a circuit by the rarer air in the higher regions, from the place where it is poſitive, to that where negative.

miles in thickneſs, as in the atmoſphere, may be quite luminous, though the light from it be diminiſhed by the diſtance from the eye. The light was fainter in every degree of the rarefaction, when there was moiſture in the tube, from my having put a little bit of wet leather in the recr (which however was dried in the exhauſtion;) and this inclines me to think, that it is *air* burnt and exploded in its paſſage which makes the electric matter viſible; and that were there no air, if it could paſs at all, it would not be luminous: for though we were to ſuppoſe, that the electric matter would be rendered luminous by mere watery vapour without any air; yet I imagine the extreme cold, in very elevated regions of the atmoſphere, would freeze this vapour, as it does near the earth, and condenſe it into icicles, deſtroying its elaſticity; ſo that it could not aſcend, by its expanſive force, beyond that height, in which there would ſtill be air, though of great tenuity: if theſe things be ſo, the Aurora Borealis is confined within our atmoſphere.

N. B. The pear-gage with its metal caſe and wire, being within the recr prevented me from knowing what would be the appearance of the electric matter in paſſing through it.

I had not an electrical machine mounted; ſo could not in theſe experiments try the effect of continual electrification, and it

it has not been in my power to repeat them: if it had I would not take the liberty to offer them to the public ſo imperfect: they are preſented as hints to direct the enquiries of others, who are ſo circumſtanced as to be able to proſecute them, and alſo as ſuggeſting perhaps the beſt teſt of the pneumatic engine's exhauſting power.

On the APPLICATION *of a* CONVERGING SERIES *to the* CONSTRUCTION *of* LOGARITHMS. *By* MR. WILLIAM ALLMAN, A. B. *Trinity College, Dublin.*

Read May 21, 1796.

FROM a due conſideration of Newton's binomial theorem, it may be ſhewn, that the logarithm of the ratio of one number to another, according to Napier's ſyſtem, is equal to the ſum of the ſeries, $\frac{2d}{s}+\frac{2d^3}{3s^3}+\frac{2d^5}{5s^5}+\frac{2d^7}{7s^7}+$ &c. d repreſenting the difference, and s the ſum of the numbers: which logarithm of the ratio, added to, or ſubtracted from, the logarithm of the antecedent, according as the antecedent is leſs, or greater, than the conſequent, gives the logarithm of the conſequent.

IN any ſyſtem whatever, the logarithm of the ratio of one number to another is equal to the ſum of this ſeries, $\frac{2pd}{s}+\frac{2pd^3}{3s^3}+\frac{2pd^5}{5s^5}+\frac{2pd^7}{7s^7}+$ &c. where d expreſſes the difference,

and

and s the ſum of the numbers, as before; and p the quote found upon dividing, the logarithm of ſome number according to that ſyſtem, by Napier's logarithm of the ſame number.

It is evident, that the leſs d is in reſpect of s, the faſter the ſeries will converge; ſo that the conſtruction of the logarithms of prime numbers, will be rendered more eaſy and expeditious, by finding two great products, which ſhall have a ſmall difference; one of which products, ſhall be compoſed entirely of factors whoſe logarithms are already known, and the other, ſhall have in its compoſition, the number whoſe logarithm is ſought, or ſome power of that number; and, if it have any other factors, the logarithms of theſe factors muſt be previouſly known.

Having found ſuch products, we may, by the application of the above-mentioned ſeries, find the logarithm of their ratio to each other; which is the ſame with the logarithm of the ratio of the firſt product (or that which is compoſed entirely of factors whoſe logarithms are known) divided by the factor or compound of factors whoſe logarithms are known (if there be any ſuch) in the latter product, to the prime number whoſe logarithm is ſought, or ſome power of that number. Then, from the logarithm of the antecedent, and the logarithm of the ratio, we have, by addition or ſubtraction, the logarithm of the conſequent.

I PROPOSE now to ſhew, how products of this nature may be found—and firſt, when they riſe to two dimenſions only, or conſiſt each of two factors.

LET the two factors of one product be $x + a$, and $x + b$; that product will then be $x^2 \overset{+\,a}{+\,b} x + ab$; if we aſſume for two other factors, the quantities x and $x \overset{+\,a}{+\,b}$ we get the product $x^2 \overset{+\,a}{+\,b} x$, which differs from the firſt product by ab, the loweſt term of that product.—Here it is obvious,

1. THAT the nearer ab approaches to o, cæteris paribus, the faſter will the ſeries converge.

2. THAT if $a + b$ be made equal to o there will be but three different factors, for $x \overset{+\,a}{+\,b}$ will then be equal to x.

3. IT may be obſerved with reſpect to products of any dimenſions whatever, that the ſame factor muſt not enter both products, for this would ſerve only to raiſe the terms of the fraction $\frac{d}{s}$; not to diminiſh its value.

4. HENCE it follows, that in ſearching for theſe products, we muſt ſuppoſe one of them to conſiſt entirely of compound factors.

5. It is convenient that they differ in their loweſt terms only; otherwiſe the quote found upon dividing their ſum by their difference (by the increaſe or decreaſe of which the convergency of the ſeries is accelerated or retarded) would be of a lower dimenſion than either product; ſo that we would be at the trouble of finding products of a higher dimenſion, when perhaps products might be found of the ſame dimenſion with the quote $\frac{s}{d}$, differing only in their loweſt terms.

Besides, if this compound difference (or ſome compound quantity which is of the ſame dimenſion with this difference and an aliquot part of it) do not meaſure either product, there is this additional inconvenience, namely, that the numerator of the fraction is uncertain, being affected by the variable quantity x; whereas if the difference of the products be the ſame with the difference of their abſolute terms, it is in no manner affected by the variation of x, and the numerator of the fraction $\frac{d}{s}$ may ſometimes be reduced to unity, which is convenient in the application of the ſeries to practice.

If the compound difference (or ſome aliquot part of it, and of the ſame dimenſions with it) meaſure either product, it is a ſure ſign that there are products of an inferior dimenſion every whit as advantageous for the conſtruction of logarithms. From all

all which we may ſee the utility of ſo adapting the products to each other, that they may differ in their loweſt terms only.

6. It is uſeful, when one of the products only conſiſts entirely of compound factors, that the ſecond terms of theſe factors be as ſmall numbers as poſſible; for the continual product of all theſe ſecond terms conſtitutes in this caſe the difference of the products. This precaution is alſo uſeful, when both products conſiſt entirely of compound factors, and their loweſt terms are, at the ſame time, affected with contrary ſigns. For the difference of the products in this caſe is equal to the ſum of two numbers which are produced by the continual multiplication of the ſecond terms of the factors of each product reſpectively, no regard being paid to their ſigns.

Substitute in the above products of two dimenſions, 1 for a, and -1 for b (by which means we ſhall have $ab = -1$, and $a + b = 0$) the products will then be $x^2 - 1$, and x^2, whoſe difference is unity and which conſiſt of but three different factors $x - 1$, $x + 1$ and x.

The logarithms of any two of theſe factors being given that of the third may be found by the application of the above mentioned ſeries; $\frac{d}{f}$ being in this caſe equal to $\frac{1}{2x^2 - 1}$.

But Dr. Halley has already ſufficiently explained this method of applying the ſeries.

To come then in the next place to products of three dimenſions, or which conſiſt each of three factors—

Let $x^3 + qx^2 + rx + s$ repreſent one of ſuch products, and let its factors be denoted by $x + a$, $x + b$ and $x + c$. Then if the ſign of the ſecond term in each factor be changed, the ſign of the firſt term in each being unvaried, the product will be $x^3 - qx^2 + rx - s$; make q, or $a + b + c = o$; we then ſhall have two products differing from each other by $2s = 2abc$; ſo that if c be taken equal to $a + b$ with their ſigns changed, the products will differ from each other in their loweſt terms only; but this difference, and at the ſame time the number of different factors, will be the leaſt poſſible (fractional numbers being ſet aſide) if we make $a = b$ and each of them equal to unity; the products then with their reſpective factors will be, $x^3 * - 3x - 2 = \overline{x + 1}^2 \times x - 2$ and $x^3 * - 3x + 2 = \overline{x - 1}^2 \times x + 2$; whoſe difference never exceeds four in whatever manner x be varied; and the number of different factors is alſo reduced to four.

That the number of different factors of ſuch products as are required of three dimenſions, cannot be leſs than four, may be thus demonſtrated; if there were but three different factors one

one product ſhould have all its factors equal to each other; the other, two of the three factors equal to each other. Let $x^3 + 3ax^2 + 3a^2x + a^3$ $(= \overline{x+a}|^3)$ repreſent one of the products, and $x^3 \begin{matrix} +2b \\ +c \end{matrix} x^2 \begin{matrix} +b^2 \\ +2bc \end{matrix} x + b^2c$ $(= \overline{x+b}|^2 \times \overline{x+c})$ the other. Then ſince theſe products ought to differ in their loweſt terms only, we have $3a = 2b + c$, and $b^2 + 2bc = 3a^2$, by comparing theſe equations with each other we find $4b^2 + 4bc + c^2 = 3b^2 + 6bc$ $\therefore b^2 = 2bc$—s^2 and $b = c$; ſo that theſe products will be both cubes, or can have but two different factors; but ſince $3a = 2b + c$, i. e. (from what has been already proved) $3a = 3b$, we have $a = b$; by which it appears that not only the ſame factor enters both products (which has been already ſhewn to be uſeleſs) but both products conſiſt entirely of the ſame factor equally repeated and are in effect *one* and the ſame product.

In the application of the products x^3—$3x$—2 and x^3—$3x + 2$, to the conſtruction of logarithms the fraction $\frac{a}{s}$ of the ſeries muſt be made equal to $\frac{4}{\overline{2x+1}|^2 \times \overline{x-2} + 4}$ or $\frac{4}{\overline{2x-1}|^2 \times \overline{x+2} - 4}$ or in its loweſt terms $\frac{1}{\frac{\overline{x+1}|^2 \times \overline{x-2}}{2}} + 1$ or $\frac{1}{\frac{\overline{x-1}|^2 \times \overline{x+2}}{2}} - 1$.

The

The ſeries will then exhibit the logarithm of the ratio of $\overline{x+1}^2 \times \frac{x-2}{x+2} : \overline{x-1}^2$, or of $\left(\frac{\overline{x+1}}{x-1}\right)^2 \times \overline{x-2} : x+2$; of $\overline{x+1}^2 : \overline{x-1}^2 \times \frac{x+2}{x-2}$, or of $x-2 : \left(\frac{\overline{x-1}}{x+1}\right)^2 \times \overline{x-2}$; where, the antecedents being leſs than the conſequents, if the logarithm of $\overline{x+1}^2$ or of $x-2$ be required, the ſum of the above ſeries is to be ſubtracted from the logarithm of $\overline{x-1}^2 \times \frac{x+2}{x-2}$ or of $\left(\frac{x-1}{x+1}\right)^2 \times x+2$, reſpectively.

The ſmaller the factor, by which any given number whoſe logarithm is ſought, is denoted, the faſter will the ſeries converge.

For the abſolute value of each factor, and therefore the value of each product, is by this means encreaſed.—Then ſince the ſum of the products is increaſed, their difference being unvaried, the ſeries will converge faſter.

Though we have this advantage by making a ſmaller factor repreſent the number whoſe logarithm is required, yet it may be objected, that this implies the neceſſity of being previouſly acquainted with the logarithms of greater numbers. But the difficulty of this, will in the preſent caſe, be removed, if the prime number whoſe logarithm is required (that number being underſtood

underſtood to exceed 3) be denoted by the factor $x-1$, when the number next leſs is meaſured by 3; or by the factor $x-2$, when the number next greater is meaſured by 3.

Of the four different factors, two are always even and two odd, the number whoſe logarithm is ſought being odd, there *can* be but one odd number greater than the given one, whoſe logarithm it is neceſſary to be previouſly acquainted with, in order to find the logarithm required. This number exceeds the given one by 2, when the given one is denoted by $x-1$; by 4 when it is denoted by $x-2$; ſo that this odd factor, greater than that which repreſents the number whoſe logarithm is ſought, will be meaſured by 3, if the given number be repreſented by $x-1$, and at the ſame time, the number next leſs be meaſured by 3; or if the given number be repreſented by $x-2$, and the number next greater be meaſured by 3; we then ſhall have all the factors, except the number whoſe logarithm is ſought, compoſite. That their component parts will be leſs than that number, is evident from the nature of the factors.

If any one wiſhes rather conſtantly to uſe the ſame notation, which may perhaps be deſirable, in conſtructing a table of logarithms, for the ſake of avoiding confuſion; when a prime factor occurs greater than that whoſe logarithm is ſought, ſo that the logarithm cannot be found immediately, let the logarithm

of

of that prime number be ſought by the ſame method as that which was to be uſed for the diſcovery of the firſt logarithm; and no prime factor will occur to prevent the logarithm of this number from being found immediately.—For, ſince, when the factor $x-1$ is taken to denote the prime number whoſe logarithm is ſought, the other odd factor exceeds it by 2; and when the factor $x-2$ is taken to denote it, the remaining odd factor exceeds it by 4; if the number exceeding the given one, when denoted by the factor $x-1$, by two, or when denoted by the factor $x-2$, by 4, be compoſite, the logarithm may be found immediately: But if, in the firſt caſe, the number exceeding the given one by 2, be prime, the number which exceeds that number by 2 (or the given one by 4) will be compoſite—and if in the other caſe, the number exceeding the given one by 4 be prime, the number which exceeds that number by 4 (or the given one by 8) will be compoſite—ſo that the method of notation remaining unvaried, no prime factor will occur to prevent the logarithm of that prime number (by the intervention of which, the logarithm firſt ſought is to be deduced) from being found immediately.

It is eaſy to ſhew, that, if the number which exceeds any prime number greater than 3, by 2, be prime, the number which exceeds it by 4, will be compoſite; or, if the number which exceeds it by 4 be prime, that number which exceeds it

it by 8 will be compoſite; for, ſince neither the given number, nor the number which exceeds it by 2, is meaſured by 3, according to the firſt ſuppoſition, the number which exceeds the given one by unity, will be meaſured by 3 (for 3 muſt neceſſarily meaſure one of three ſucceſſive numbers) and therefore the number exceeding the given one by 4 will be meaſured by 3. Since, in the ſecond place, either the number which exceeds the given one by 2, or that which exceeds it by 4 is meaſured by 3; if the number which exceeds it by 4 be prime, that which exceeds it by 2, and therefore, that alſo which exceeds it by 8, will be meaſured by 3.

It were eaſy to ſhew, that, in the application of the above products of three dimenſions, differing by 4, to the conſtruction of logarithms, the numerator of the fraction $\frac{d}{s}$ reduced to its loweſt terms is always unity. In this caſe $\frac{d}{s} = \frac{2}{\overline{x+1|^2} \times \overline{x-2} + 2}$. Now, ſince either $\overline{x+1}^2$, or $x-2$, is even, 2 will meaſure their product increaſed by 2.

Make $\frac{\overline{x+1}^2 \times \overline{x-2}}{2} + 1 = y$; the general ſeries will then be reduced to this form, $\frac{2p}{y} + \frac{2p}{3y^3} + \frac{2p}{5y^5} + \frac{2p}{7y^7} +$, &c. Half the

ſum of this ſeries will expreſs the logarithm of the ratio of $\overline{x+1} \times \overline{\frac{x-2}{x+2}}^{\frac{1}{2}} \cdot x-1$ or of $x+1 \cdot \overline{x-1} \times \overline{\frac{x+2}{x-2}}^{\frac{1}{2}}$

If two products of any dimenſions whatever, differ in their loweſt terms only, and the ſecond terms of all the factors in each product be equally multiplied; the products of the factors ſo changed will ſtill differ in their loweſt terms only, but the difference in this caſe will be the difference of the original products multiplied into the common multiplier of the ſecond terms of the factors raiſed to the ſame dimenſion with the higheſt term of either product. For the terms of the original products, beginning with the higheſt term in each, are reſpectively multiplied by the terms of a geometrical progreſſion, whoſe firſt term is unity, and ſecond the common multiplier; ſo that the terms of the latter products, which are correſpondent to terms that were equal in the firſt products, will be equal to each other; and the terms of the latter, correſpondent to thoſe which differed in the firſt products, will have a difference equal to the difference of the terms in the firſt products, multiplied by the correſpondent term of the geometrical progreſſion above-mentioned.

Let m denote the common multiplier, and n the index of the higheſt term in the products; the geometrical progreſſion will ſtand thus, $1, m, m^2, m^3$, &c. , m^n. Let the latter products be both

both divided by m^n; the quotes will have the ſame ratio as the latter products, and the ſame difference as the firſt products have. Now the terms of the firſt products multiplied by the correſpondent terms of this progreſſion, $\frac{1}{m^n}, \frac{1}{m^{n-1}}, \frac{1}{m^{n-2}}, \frac{1}{m^{n-3}}$ &c. $\frac{1}{m^3}, \frac{1}{m^2}, \frac{1}{m^1}, 1$ (i. e. the terms of the preceding progreſſion divided by m^n) gives the correſpondent terms of the quotes; ſo that if m be greater than 1, the terms of the quotes will be leſs than the terms of the firſt products reſpectively.—The contrary to this happens, if m be a proper fraction—In this laſt caſe then, the ſum of the quotes being greater than that of the firſt products, while the difference is the ſame; and the difference of the quotes having the ſame ratio to their ſum, as the difference of the latter products to their ſum, it appears that the difference of the latter products bears a leſs ratio to their ſum, than the difference of the firſt products bears to their ſum; ſo that if the ſecond terms of the factors of products differing in their loweſt terms only, be all multiplied by the ſame proper fraction, the ſeries expreſſing the logarithm of the ratio of the products to each other will converge faſter.

If the ſecond terms of the factors of products differing in their loweſt terms only, be equally increaſed by addition or

diminiſhed by ſubtraction, the products will ſtill have the ſame difference.

LET the coefficients of the 2d, 3d, 4th, 5th, &c. terms of the given products be denoted by q, r, s, t, v, &c reſpectively; the index of the higheſt term by w, and the quantity, whether affirmative or negative, which is to be added to each of the ſecond terms of the factors, by m, the coefficients of the correſpondent terms of the new products will be, $\frac{n}{1}.m$, $\frac{n}{1}.\frac{n-1}{2}.m^2$, $\frac{n}{1}.\frac{n-1}{2}.\frac{n-2}{3}.m^3$ $\frac{n}{1}.\frac{n-1}{2}.\frac{n-2}{3}.\frac{n-3}{4}m^4$, &c.

q	$\frac{n-1}{1}qm$	$\frac{n-1}{1}.\frac{n-2}{2}qm^2$	$\frac{n-1}{1}.\frac{n-2}{2}.\frac{n-3}{3}qm^3$
	r	$\frac{n-2}{1}rm$	$\frac{n-2}{1}.\frac{n-3}{2}rm^2$
		s	$\frac{n-3}{1}sm$
			t.

WHENCE it appears that in whatſoever term the given products begin to differ from each other in the correſpondent one, will the new products alſo begin to differ from each other, and by the ſame quantity. If the ſecond terms of the factors be *equally* increaſed, the ſum of the products will be increaſed, ſo that (if

(if the abſolute value of the leading term be unvaried) the ſeries will converge faſter. If then the given number whoſe logarithm is ſought, be denoted by a ſimple quantity x, the lower the place which the ſimple quantity occupies among the factors, or the fewer reſidual factors there are, the faſter will the ſeries converge.—Now whatever compound quantity be ſubſtituted for this ſimple one, the effect will be the ſame, viz. that the convergency of the ſeries is quicker or ſlower, the lower or higher the place which the given number occupies in the rank of factors.

But ſince it is uſeful that the difference of the greateſt and leaſt factor ſhould be as ſmall as poſſible (as follows from what has been obſerved before) the advantage of a ſwifter convergency, will, generally ſpeaking, be in a leſs degree in this caſe, than the ſimilar advantage which ariſes from multiplying the ſecond term of each factor by an aliquot fraction, or (which amounts to the ſame thing) the leading term of each factor by the reciprocal integer.

From what has been ſaid it follows, that if, of the firſt and ſecond, fourth and fifth terms of an arithmetical progreſſion, the logarithms of any three be given, the logarithm of the remaining term may be found. If the common difference of the progreſſion be unity, $\frac{d}{s}$, will be equal to an aliquot fraction, whoſe

denominator

denominator exceeds, by 1, half the product, whose factors are the firſt or loſt term of the progreſſion, and the ſquare of the fourth term; if the common difference be any other number, ſuppoſe m; $\frac{d}{s}$ will be equal to that aliquot fraction above deſcribed, multiplied by m^3. The general ſeries will then expreſs the logarithm of the ratio which the product of the firſt term into the ſquare of the fourth, bears to the product of the fifth term into the ſquare of the ſecond. This, ſince the arithmetical progreſſion is an increaſing one, will be a ratio of leſſer inequality.

It alſo appears, that there is no reſtriction ſet on finding the moſt convenient products, by the ſuppoſition that one of them is defective in its loweſt term. And that, in the inveſtigation of products, if we find ſecond terms which (all of them being equally diminiſhed ſo that one may vaniſh) will then admit a common meaſure, the products may then be reduced to a ſmaller difference.

Let $x^4 + qx^3 + rx^2 + sx + t$ repreſent a product of four dimenſions, and let s be $= o$, two factors are to be found, whoſe product ſhall be $x^2 + qx + r$; this being multiplied by x^2 will give the product $x^4 + qx^3 + rx^2$, differing from the firſt product by t the loweſt term

term of that product. Suppose one of the factors to be $x+m$; the other will be $x \overset{+q}{-} m$. Then $qm - m^2 = r \therefore m = \frac{q}{2} \mp \sqrt{\frac{q^2}{4} - r}$, and $q - m = \frac{q}{2} \mp \sqrt{\frac{q^2}{4} - r}$. Let the factors of the product $x^4 + qx^3 + rx^2 + sx + t$ be $x+a$, $x+b$, $x+c$, and $x+d$. And the factors of the product $x^3 + qx + r$ will be, $x + \frac{a+b+c+d}{2} \pm \sqrt{\frac{a+b+c+d}{4}^2 - ab - ac - ad - bc - bd - cd}$, or (which is the same thing) $x + \frac{a+b+c+d}{2} \pm \sqrt{\frac{a+b-c-d}{4}^2 - ab - cd}$. These factors will be always rational (whatever may be the values of a, b, c, and d, provided they be rational) if we make $ab + cd = o$. Then since s, or $abc + abd + acd + bcd = o$, we have $\frac{cd}{b} (= -a) = \frac{bcd}{bc + bd + cd}$. And dividing by cd and multiplying by the denominators, $bc + bd + cd = b^2$. Therefore $c = \frac{b^2 - bd}{b+d}$, $d = \frac{b^2 - bc}{b+c}$ and $b = \frac{c+d}{2} \pm \sqrt{\frac{c+d}{4}^2 + cd}$. So that if b be rational, c, d, and a (or $-\frac{cd}{b}$) will also be rational. But b will be rational, if $c^2 + 6cd + d^2$ be a perfect square. Make $c^2 + 6cd + d^2 = c^2$. Then $6cd + d^2 = o$ and $d = -6c$. Universally, putting $c^2 + 6cd + d^2 = c^2 + 2cn + n^2$, we have $6d - 2n$. $c = n^2 - d^2$ and

and $c = \frac{n^2 - d^2}{6d - 2n}$. Only we muſt not aſſume $n = d$ or $= -d$; or $= 3d$, for on the two firſt aſſumptions we ſhould get $\overline{6d - 2n}$. $c = o$, i. e. either $4dc$, or $8dc = o$; on the third aſſumption, $n^2 - d^2 = o$, i. e. $8d^2 = o$; ſo that either c or d would be equal to o; contrary to what has been above laid down.

MAKE $c = -1$ and $d = 6$; then $b = 2$ or 3, let $b = 2$; and we ſhall have $a = 3$. And m, as alſo $q - m$, $= 5$.

THEN we have the factors $x - 1$, $x + 2$, $x + 3$, $x + 6$, whoſe product ſhall be deficient in its penultimate term, and ſhall differ by 36 its loweſt term, from the product of the factors x^2 and $\overline{x + 5}^2$; as will appear by their multiplication.

$x + 6$
$x + 3$
$x^2 + 9x + 18$
$x + 2$
$x^3 + 11x^2 + 36x + 36$
$x - 1$
$x^4 + 10x^3 + 25x^2 * - 36$

$x + 5$
$x + 5$
$x^2 + 10x + 25$
x^2
$x^4 + 10x^3 + 25x^2$

IN

In the ſecond product, we may obſerve that there are but two different factors. That the factor $x + m$ muſt be equal to the factor $x \overset{+q}{-m}$, or that m is equal to $\frac{q}{2}$, will appear if it be ſhewn that $\frac{q^2}{4} - r$ or $\frac{\overline{a+b-c-d}^2}{4} - ab - cd = o$; which may be done in the following manner:—Since $ab + cd = o$, we alſo have by multiplication, $a^2 b + acd = o$, $ab^2 + bcd = o$, $abc + c^2 d = o$, and $abd + cd^2 = o$.

By comparing theſe four equations ſeverally with the equation, $abc + abd + acd + bcd = o$, we find,

$$\begin{aligned} a^2 &= ac + ad + cd \\ b^2 &= bc + bd + cd \\ c^2 &= ab + ac + bc \\ d^2 &= ab + ad + bd \end{aligned}$$

$a^2 + b^2 + c^2 + d^2 = 2ab + 2ac + 2ad + 2bc + 2bd + 2cd.$ And therefore $\overline{a+b-c-d}^2 = 4ab + 4cd \therefore \frac{\overline{a+b-c-d}^2}{4} - ab - cd = o.$ Q. E. D.

That the number of different factors in both products cannot be leſs than ſix, without introducing ſurds, may be ſhewn as follows:

First, neither product can have three factors alike—Since, by a change in all the ſecond terms, any factor may be reduced to a ſimple expreſſion; let the factor which occurs three times be denoted by x, the product will then be deficient in the three loweſt terms—the other product that it may differ from this by its loweſt term only, muſt want the penultimate and antepenultimate terms; at the ſame time, retaining the laſt; ſo that two of its factors will be impoſſible.

The above is evidently applicable to products of all dimenſions; and from this immediately follows what has been proved above, relative to the leaſt number of different factors in products of three dimenſions.

Hence it appears that the leaſt poſſible number of different factors will not be leſs than the index of the higheſt term in either product, if that index be even—if it be odd, the leaſt poſſible number of different products will be greater than the index.

Whence it follows that the number of different factors in the preſent caſe cannot poſſibly be leſs than four.

But in the next place, the number of different factors cannot without introducing ſurds, be leſs than ſix.

For

For if we ſuppoſe but five different factors in both products, two of them muſt be in one product, and three in the other, ſince neither product can conſiſt entirely of equal factors, as appears from the above, and neither of thoſe two factors muſt be taken three times. Let the factors of one product then be be x^2 and $\overline{x+m}^3$, and the factors of the other $x+a$, $x+b$, $\overline{x+c}^3$. The reſpective products will be $x^4 + 2mx^3 + m^2x^2$, and

$$x^4 \begin{matrix} +a \\ +b \\ +2c \end{matrix} x^3 \begin{matrix} +ab \\ +2ac \\ +2bc \\ +c^2 \end{matrix} x^2 \begin{matrix} +2abc \\ +ac^2 \\ +bc^2 \end{matrix} x + abc^2.$$

That theſe products may differ only in the loweſt term theſe three limitations are neceſſary. We muſt make firſt, $a+b+2c = 2m$; ſecondly, $ab + 2ac + 2bc + c^2 = m^2$; and thirdly, $2abc + ac^2 + bc^2 = 0$. From the two firſt equations we have, $a^2 + 2ab + b^2 + 4ac + 4bc + 4c^2$ $(= 4m^2) = 4ab + 8ac + 8bc + 4c^2$ $\because a - 2ab + b^2 = \overline{4a+4b} \times c$. From the third equation, we have $2ab + ac + bc = 0$, $\because c = -\frac{2ab}{a+b}$. This value of c being ſubſtituted in the equation $a^2 - 2ab + b^2 = \overline{4a+4b} \times c$, there ariſes $a^2 - 2ab + b^2 = -8ab$,

$-8ab$, $\because a^4 = -6ba - b^4$ and $a = -36 \pm 2b\sqrt{2}$; ſo that either b, or a, will be embarraſſed with a ſurd.

Let the prime number whoſe logarithm is ſought by the application of the above products of four dimenſions, be denoted by $x + 2$, if the number next greater is meaſured by 3; by $x + 3$, if the number next leſs be meaſured by 3—and then all the other factors will be compoſite. For in the firſt caſe, $x - 1$ will be meaſured by 2; x, by 3; $x + 3$, by both 2 and 3; $x + 5$, by 2; and $x + 6$, by 3: In the other caſe, $x - 1$, will be meaſured by 3; x, by 2; $x + 2$, by both 2 and 3; $x + 5$, by 3; and $x + 6$, by 2.

If the prime number, whoſe logarithm is ſought, were denoted by any other factor than $x + 2$, or $x + 3$, other diviſors, beſides 2 and 3, ſhould come into conſideration; for in any caſe there would be at leaſt another factor, which, neither 2, nor 3, would meaſure.

Using then the notation directed above, the ratio of $x^2 \times \overline{x+5}^2$ to, $\overline{x-1} \times \overline{x+2} \times \overline{x+3} \times \overline{x+6}$, of $\frac{x^2 . \quad \overline{x+5}^2}{\overline{x-1} . \; \overline{x+3} . \; \overline{x+6}}$

$: x + 2$,

$: x + 2$, or of $\frac{x^2 . \overline{x+5}^2}{x-1 . x+2 . x+6} : x + 3$, will always be a ratio of greater inequality.

IN the application of theſe factors to the conſtruction of logarithms $\frac{d}{s} = \frac{36}{2 . x^2 . \overline{x+5} - 36}$, which fraction (the above notation being uſed) when reduced to its loweſt terms will have unity for its numerator. For, of x and $x + 5$, 2 always meaſures one, and 3 the other, as appears from what has been ſaid above; therefore 4 meaſures the ſquare of one; and 9, the ſquare of the other (the quote of two ſquare numbers being equal to the ſquare of the quote of their roots; which laſt is in this caſe an integer) conſequently 36 meaſures the product of their ſquares (the continual product of any factors being the ſame, in whatever order the factors be taken) and therefore it alſo meaſures double that product diminiſhed by 36; i. e. $2 . x^2 . \overline{x+5}^2 - 36$. Put the quote $\frac{2 . x^2 . \overline{x+5}^2}{36} - 1 = y$; $\frac{d}{s}$ will then be equal to $\frac{1}{y}$, by ſubſtitution of which the expreſſion of the general ſeries will be rendered more ſimple as before.

THE

The inveſtigation of products of five dimenſions may be at preſent omitted.—For the difference of the products of five dimenſions, which ſeem moſt commodious for the conſtruction of logarithms, is ſo great as to deſtroy a conſiderable part of the advantage ariſing from the greatneſs of their ſum.——Beſides the very invention of theſe products, eſpecially when the factors are large, is troubleſome.—Not to mention the number of additions and ſubtractions neceſſary to find the logarithm required, after the logarithm of the ratio, as directed by the ſeries, has been found.

This laſt objection indeed, would be of much leſs weight were products found whoſe difference ſhould bear ſo ſmall a ratio to their ſum, as to preclude the neceſſity of uſing a ſingle term of the ſeries.

If $x \pm a$, $x \pm b$, $x \pm \begin{matrix} \mp a \\ + b \end{matrix}$, denote the reſpective factors of two products; theſe products will be $x^3 * \begin{matrix} -a^2 \\ -ab. \\ -b^2 \end{matrix} x \mp ab. \overline{a+b}.$

Their arithmetical mean $x^3 * \begin{matrix} -a^2 \\ -ab. \\ -b^2 \end{matrix} x$, will be reſolvable into three ſimple and rational factors; if $a^2 + ab + b^2$, be a perfect ſquare.

ſquare. Make $a^2 + ab + b^2 = a^2 - 4ab + 4b^2$. Then will $5ab = 3b^2$ and $5a = 3b$. Let $b = 5 \therefore a = 3$. The products then with their reſpective factors will be $x^3 * - 49x - 120 = \overline{x+3} \times \overline{x+5} \times \overline{x-8}$; and $x^3 * - 49x + 120 = \overline{x-3} \times \overline{x-5} \times \overline{x+8}$. And the factors of the arithmetical mean $x^3 - 49x$, will be $x - 7$, x, $x + 7$.

The ſquare of the arithmetical mean, $x^6 - 98\,x^4 + 2401\,x^2$, differing from the product of the extremes, $x^6 - 98\,x^4 + 2401\,x^2 - 14400$ by the abſolute term 14400. Here then we have two products of ſix dimenſions, which though they have a difference conſiderably greater, than the products already given of lower dimenſions, may yet be of ſome uſe in the conſtruction of logarithms.

Having ſhewn different methods of diminiſhing the value of the fraction $\frac{d}{s}$, in the application of the above general ſeries to the conſtruction of logarithms, by which means the ſeries will be made to converge faſter; I proceed now to an abbreviation of the ſeries itſelf, which will ſerve to compute the logarithms even of ſmall numbers to a much greater degree of accuracy, with ſcarce any increaſe of trouble.

In

If we put $y = \frac{s}{p}$, the ſeries may be expreſſed thus; $2p \times \frac{1}{y} + \frac{1}{3y^3} + \frac{1}{5y^5} + \frac{1}{7y^7} +$ &c. which may be changed into the following equivalent one, $2p \times \frac{1}{y} + \frac{10}{30y^3 - 18y} + \frac{36}{1575y^7 - 2695y^5}$ — &c. whoſe two firſt terms are even more accurate than the three firſt of the preceding—and its three firſt terms more accurate than five of that ſeries.

The ſecond and third terms of the above ſeries being reduced to a common denominator, their value is $\frac{5y^2 + 3}{15y^5}$. Upon dividing the denominator of this fraction by its numerator and taking the two firſt terms only of the quote for a new denominator, and unity for a numerator, we get the fraction $\frac{1}{3y^3 - \frac{2}{5}y}$ or $\frac{10}{30y^3 - 18y}$; which, reduced to an equivalent one whoſe denominator is $15y^5$, becomes $\frac{5y^2 + 3 + \frac{9}{5y^2} + \frac{27}{25y^4} + \frac{81}{125y^6} + \frac{243}{625y^8} + \text{&c.}}{15y^5}$ the terms of the numerator decreaſing in the ratio of $5y^2 : 3$, i. e. in the ratio of the terms of the numerator of the fraction, which ariſes from the union of the ſecond and third terms of the ſeries.

Then

Then ſince $\frac{10}{30y^3 - 18y} = \frac{5y^2 + 3}{15y^5} + \frac{3}{25y^7} + \frac{0}{125y^9} + \frac{27}{625y^{11}} + \frac{81}{3125y^{13}}$ + &c. we have $\frac{5y^2 + 3}{15y^5} = \frac{10}{30y^3 - 18y} - \frac{3}{25y^7} - \frac{9}{125y^9} - \frac{27}{625y^{11}} - \frac{81}{3125y^{13}}$ — &c. which being ſubſtituted for the ſecond and third terms of the ſeries, we get the ſeries in this form, $2p \times \frac{1}{y} + \frac{10}{30y^3 - 18y} + \frac{4}{175y^7} + \frac{44}{1125y^9} + \frac{328}{6875y^{11}} + \frac{2072}{40625y^{13}}$ + &c.——Again; the terms $\frac{4}{175y^7}$ and $\frac{44}{1125y^9}$, (which are of the ſame dimenſions with the fourth and fifth terms of the firſt ſeries) being reduced to a common denominator, their value is $\frac{180y^2 + 308}{7875y^9}$; which, by a proceſs ſimilar to that already uſed, may be ſhewn to be equivalent to, $\frac{36}{1575y^7 - 2695y^5} - \frac{3388}{50625y^{11}} - \frac{260876}{2278125y^{13}}$ — &c. the terms after the firſt, decreaſing in the ratio of $180y^2 : 308$, or of $45y^2 : 77$.

Then, by ſubſtitution, the ſeries comes out in this form: $2p \times \frac{1}{y} + \frac{10}{30y^3 - 18y} + \frac{36}{1575y^7 - 2695y^5} - \frac{428}{2275y^{11}} - \frac{75236}{1184625y^{13}}$ — &c.

The two firſt terms of this ſeries may be uſed to very conſiderable advantage; with much the ſame trouble as the two firſt terms of the original ſeries; and with rather greater accuracy than the three firſt terms of that ſeries.

If a third diviſion be required, this may be ſomewhat altered for the convenience of continual diviſions. Thus:
$\frac{2p}{y} + \frac{10}{30y^2 - 18} \cdot A + \frac{108}{9y^2 - 1.\ y^2 - 1.\ 175} \cdot B$ — &c. the letters A, B, &c. denoting the terms as they ariſe.

The three firſt terms of this ſeries are more accurate than three of the preceding; which likewiſe are more accurate than the five firſt terms of the original ſeries.

A few examples may ſerve to illuſtrate what has been ſaid.

Note, that Briggs's logarithm of 10 (which is 1,) divided by Napeir's logarithm of 10, (or, 2, 30258. 50929. 94045. 68401. 79914. 54684. 36420. 76011. 01488 &c.) the quote is, 43429. 44819. 03251. 82765. 11289. 18916. 60508. 22943. 97005 &c. $= p$. Then, ,86858. 89638. 06503. 65530. 22578. 37833. 21016. 45887.

45887. 94001 &c. $= 2p$. And, ,18861. 16970. 11613. 92922. 42603. $= p^2$.

LET it be required to find Briggs's logarithm of 101.

FIRST, by Dr. Halley's method, or by the application of products of two dimenſions.

$x-1$ x $x+1$
100 101 102

$\overline{x-1.x+1} = 10200$

$2.\overline{x-1.x+1}+1 = 20401 = y$

Log. ratio of $\overline{\overline{x-1.x+1}}^{\frac{1}{2}} : x = \frac{p}{y} +$ &c. which is to be added to the logarithm of the antecedent, to find that of the conſequent the ratio of $\overline{x-1.x+1} : x^2$, being one of leſſer inequality.

20401) ,43429. 44819. 03251. 82765. 11289 (,00002. 12879. 01666.

(74436. 68276 &c. $= \frac{p}{y}$.

$x-1 = 100$ Log. 2,

$x+1 = 102$ 2, 00860 01717 61917 56104 89366 92

$\overline{x-1.x+1}$ 4, 00860 01717 61917 56104 89366 92

$\overline{\overline{x-1.x+1}}^{\frac{1}{2}}$ 2, 00430 00858 80958 78052 44683 46

Ratio of, $\overline{\overline{x-1.x+1}}^{\frac{1}{2}} : x$ 2 12879 01666 74436 68276 62 true to the 14th decimal place.

$x = 101$ Log. 2, 00432 13737 82625 52489 12960 08 true to the 14th place.

Secondly, by the application of products consisting of three factors.

$x-2$ $x-1$ $x+1$ $x+2$
101 102 * 104 105

52
52
104
260
2704
101
2704
2704

$\frac{\overline{x+1}^2}{4} = 2704$

$\frac{\overline{x+1}^2 \times x-2}{4} = 273104$

$\frac{\overline{x+1}^2 : \overline{x-2}}{2} + 1 = 546209 = y$

Log. ratio of $\overline{x+1}^2 \times \overline{x-2} : \overline{x-1}^2$.

$x\overline{x+2} = \frac{2p}{y} +$ &c. Therefore, log. ratio of $x-2 : \frac{\overline{x-1}^2}{x+1} \times x+2 = \frac{2p}{y} +$ &c.

Which, as the ratio is one of leſſer inequality, being ſubtracted from the logarithm of the conſequent, gives the logarithm of the antecedent.

546209) ,86858 89638 06503 65530 22578 (,00000 15902 13569

(90914 40369 &c. $= \frac{2p}{y}$

$x-1 = 102$	Log.	2, 00860 01717 61917 56104 89366 92
$x+1 = 104$		2, 01703 33392 98780 35484 77218 42
$\frac{x-1}{x+1}$		—, 00843 31675 36862 79379 87851 50
$\frac{\overline{x-1}^2}{x+1}$		—, 01686 63350 73725 58759 75703 00
$x+2 = 105$		2, 02118 92990 69938 07279 35052 67
$\frac{\overline{x-1}^2}{x+1} \times x+2$		2, 00432 29639 96212 48519 59349 67
Subtract log. ratio		15902 13569 90914 40369 94 true to the 18th decimal place.
$x-2 = 101$	Log.	2, 00432 13737 82642 57605 18979 73 true alſo to the 18th place.

THIRDLY,

THIRDLY, by the application of products of four dimensions.

$x-1$ x $x+2$ $x+3$ $x+5$ $x+6$

98 99 * 101 102 * 104 105

$\frac{x}{3} = 33$ $\frac{x+5}{2} = 52$

33 52

99 104

99 260

$\frac{x^2}{9} = 1089$ $\frac{\overline{x+5}^2}{4} = 2704$

1089

24336

21632

2704

$\frac{x^2 \times \overline{x+5}^2}{36} = 2944656$

$\frac{2.x^2 \times \overline{x+5}^2}{36} - 1 = 5889311 = y$

Log. ratio of $x^2 . \overline{x+5}^2$ $: x-1 . x+2 \; x+3 . x+6$, or of $\frac{x^2 \; \overline{x+5}^2}{x-1 \; x+3 \; x+6}$ $: x+2 = \frac{2p}{y}$ + &c.

Which is to be subtracted from the logarithm of the antecedent to find the logarithm of the consequent, the ratio being (as has been said above) one of greater inequality.

5889311)

5889311) ,86858. 89638. 06503. 65530 22578 (,00000 01474.
85667. 47561. 87362 &c. $= \frac{2p}{y}$

$x = 99$ Log.	1, 99563 51945 97549 91534 02557 77
$x + 5 = 104$	2, 01703 33392 98780 35484 77218 42
$x \cdot \overline{x + 5}$	4, 01266 85338 96330 27018 79776 19
$x^2 \cdot \overline{x + 5}^2$	8, 02533 70677 92660 54037 59552 39
$x - 1 = 98$	1, 99122 6 756 92494 85663 81714 12
$x + 3 = 102$	2, 00860 01717 61917 56104 89366 92
$x + 6 = 105$	2, 02118 92990 69938 07279 35052 67
Ratio of $\frac{x^2 \cdot \overline{x + 5}^2}{x - 1 \cdot x + 3 \cdot x + 6} : x + 2$	1474 85667 47561 87362 67
	6, 02101 56940 10017 96609 93496 38
$x + 2 = 101$ Log.	2, 00432 13737 82642 57427 66056 01 true to the 21ſt place.

The firſt term of the ſeries, exhibiting the logarithm of the ratio true to the 21ſt place.

If the ſecond term of the ſeries, as it exiſts in its contracted form, (viz. $\frac{10}{30y^2 - 18} \cdot A$, or, $2p \cdot \frac{10}{30y^3 - 18y}$) were uſed, we ſhould obtain the logarithm of the ratio true, by the firſt method, to the 32d decimal place; by the ſecond to the 42d, and by the third method, to the 49th.

The

The principal uſe of the factors of the products of ſix dimenſions in the conſtruction of logarithms, will appear, when (by reaſon of the greatneſs of the products which would ariſe) it becomes unneceſſary to uſe a ſingle term of the ſeries.

Thus; if it be ſufficient to have the logarithms of numbers true to 7 places of decimals, the logarithms of numbers exceeding 100 may be found by this method. Let the logarithm ſought, be that of 101, as before.

$x-8=86$	Log. 1, 93449 84512	The logarithm of the ratio of,
$x-5=89$	1, 94939 00066	$\overline{x-8}.\overline{x-5}.\overline{x-3}.\overline{x+3}.\overline{x+5}.$
$x-3=91$	1, 95904 13923	$\overline{x+8}:\overline{x-7}^{2}.x^{2}.\overline{x+7}^{2}=\frac{2p}{y}$ &c.
$x+3=97$	1, 98677 17343	Therefore the logarithm of the
$x+5=99$	1, 99563 51946	ratio of,
$x+8=102$	2, 00860 01718	
	11, 83393 69508	$\frac{\overline{x-8}.\overline{x-5}.\overline{x-3}.\overline{x+3}.\overline{x+5}.\overline{x+8}^{\frac{1}{2}}}{\overline{x-7}.x}$
	5, 91696 84754	$:x+7=\frac{p}{y}$ &c. y being taken
$x-7=87$	1, 93951 92526	equal to $\frac{2.\overline{x-7}^{2}.x^{2}.\overline{x+7}^{2}}{14400}-1$;
$x\quad=94$	1, 97312 78536	
	3, 91264 71062	i. e. in the preſent inſtance
$x+7=101$	Log. 2, 00432 13692	94755 506, 845. So that the
true to the 8th decimal place.		logarithm

logarithm found will differ from the truth by leſs than half an unit in the 8th place of decimals.

HERE the number whoſe logarithm is ſought, being denoted by the factor $x+7$, the logarithm comes out leſs than the truth; if the number were denoted by the factor $x+8$, we ſhould get the logarithm greater than the truth. The reaſon of this is manifeſt, from the relation between the products.

THE logarithms of numbers exceeding 300 may be found by this method to 10 places of decimals. And the logarithms of numbers exceeding 1300, to 14 places.

A SIMILAR application may be made of the factors of the products of four dimenſions, which will ſerve to conſtruct the logarithms of numbers exceeding 20,000 to fourteen places of decimals; ſo that, if neceſſary, we may have an eaſy way of compleating the chiliads omitted by Briggs. E. G. Let it be propoſed to find the logarithm of 19997, being even ſomewhat leſs than 20000.

$x=19995$.

$x = 19995$	Log 4, 30092 14084 6954	The logarithm of the ratio of $x^2 . \overline{x+5}^2 : \overline{x-1} . \overline{x+2} . \overline{x+3} . \overline{x+6} = \frac{2p}{y}$ + &c. But $y = \frac{2 . x^2 . \overline{x+5}^2}{36} - 1$, i. e. in this instance 88844 44499 99999 9.—So that the logarithm of the ratio will be less than unit of the sixteenth place of decimals.
$x+5 = 20000$	4, 30102 99956 6398	
$x \times \overline{x+5}$	8, 60195 14041 3352	
$x^2 \times \overline{x+5}^2$	17, 20390 28082 6704	
$x-1 = 19994$	4, 30089 96877 7225	
$x+3 = 19998$	4, 30098 65640 4417	
$x+6 = 20001$	4, 30105 17098 4522	
	12, 90293 79616 6164	
$x+2 = 19997$	Log. 4, 30096 48466 0540	

The computation of the logarithms of small numbers may be rendered more expeditious if, instead of attempting immediately to find the logarithm required, by the application of any of the preceding methods as they are above exemplified, we seek the logarithm of such a multiple of the given number, as shall not have any of its prime factors greater than that number—with the same limitation also, on the numbers which are concerned in computing the logarithm of this multiple.

E. G. If it were propoſed to find the logarithm of 31, the multiple by means of which it would be moſt conveniently found by the application of products of two dimenſions, is according to Briggs, 341. Then, $17 \times 20 = 340 = x - 1$, $11 \times 31 = 341 = x$ and $18 \times 19 = 342 = x + 1$. Whence the logarithms of 340 and 342 being known from the logarithms of their prime factors, that of 341 may be found by Dr. Halley's method—from which the logarithm of 11 being ſubtracted we get the logarithm of 31. Here $y = 2 \times 340 \times 342 + 1 = 232561$. So that uſing only the firſt term of the ſeries we get the logarithm true to the 17th place. If we uſe the products of three dimenſions, the advantage will be conſiderably greater.

The logarithm of 31 may be found from that of 899, which laſt may be found by this method without knowing the logarithm of any prime number greater than 31. For $\overline{2^7} \times 7 = 896 = x - 2$; $3 \times 13 \times 23 = 897 = x - 1$; $29 \times 31 = 899 = x + 1$ and $\overline{2 \times 3 \times 5}^2 = 900 = x + 2$. Here we have, $y = \frac{\overline{899}^2 \times 896}{2} + 1 = 362074049$. The firſt term of the ſeries gives the logarithm of the ratio true to the 27th place—without uſing even a ſingle term of the ſeries, we find the logarithm true to the ninth decimal place.

If

If the logarithm of the number 7 be required it may be found from that of 28. Here $\overline{2}^3 \times 3 = 24 = x - 2$, $\overline{5}^2 = 25 = x - 1$, $\overline{3}^3 = 27 = x + 1$, and $\overline{2}^2 \times 7 = 28 = x + 2$. And $y = \frac{27^2 \times 24}{2} + 1 = 8749$. If we uſe the two firſt terms of the ſeries as it was firſt laid down, we may find the logarithm to 19 places of decimals. But if we uſe the two firſt terms of the contracted ſeries, which may be done with only the additional trouble ariſing from diminiſhing the ſecond diviſion by 1, 8, we may get the logarithm true to 28 places.

It is manifeſt that the logarithm of ſome number muſt be found by the immediate application of the ſeries. If then Napier's logarithm of $1\frac{1}{4}$ be found by this method, we thence obtain the logarithm of $\frac{125}{64}$. The logarithm of $\frac{128}{125}$ being found in the ſame manner, and added to that of $\frac{125}{64}$, gives Napier's logarithm of 2. If the logarithms be required of Briggs's form, having found Napier's logarithm of 8, from his logarithm of 2, by adding the logarithm of $1\frac{1}{4}$ as already found, we get Napier's logarithm of 10; the reciprocal of which will be the modulus of

Briggs's ſyſtem, repreſented by p in the ſeries; by which if Napier's logarithms of $\frac{5}{4}$, and $\frac{128}{125}$ be multiplied we ſhall get Briggs's logarithms of the ſame numbers. If then we ſubtract Briggs's logarithm of $\frac{5}{4}$, from his logarithm of 10, and divide the remainder by 3; or if we add Briggs's logarithm of $\frac{128}{125}$ to his logarithm of 1000, and divide the ſum by 10; we ſhall have Briggs's logarithm of 2.—The logarithm of 2 being found, the logarithms of all other numbers may have their computation facilitated by ſome one or other of the preceding methods of increaſing the convergency of the ſeries.

As a due application of the binomial theorem furniſhes us with a ſeries for finding the logarithm of any natural number, (which is the ſame with the logarithm of the ratio of that number to unity) ſo likewiſe it may be ſhewn from the ſame principles that the ſum of the ſeries $1 + \frac{l}{1} + \frac{l^2}{1.2} + \frac{l^3}{1.2.3} + \frac{l^4}{1.2.3.4} +$ &c. will be the natural number correſponding to Napier's logarithm l; and

l; and that the ſum of the ſeries $1 - \frac{l}{1} + \frac{l^2}{1.2} - \frac{l^3}{1.2.3} + \frac{l^4}{1.2.3.4} -$ &c. will be the natural number correſponding to Napier's logarithm $-l$.

If l denote Napier's logarithm of the improper fraction $\frac{b}{a}$, then will $-l$ be Napier's logarithm of its reciprocal $\frac{a}{b}$.——

Therefore,

$$\frac{b}{a} = 1 + l + \frac{l^2}{2} + \frac{l^3}{6} + \frac{l^4}{24} + \frac{l^5}{120} + \frac{l^6}{720} + \frac{l^7}{5040} + \frac{l^8}{40320} + \text{&c.}$$

$$\frac{a}{b} = 1 - l + \frac{l^2}{2} - \frac{l^3}{6} + \frac{l^4}{24} - \frac{l^5}{120} + \frac{l^6}{720} - \frac{l^7}{5040} + \frac{l^8}{40320} - \text{&c.}$$

$$\frac{b^2 - a^2}{ab} = 2l + \frac{l^3}{3} + \frac{l^5}{60} + \frac{l^7}{2520} + \text{&c.}$$

$$\frac{b^2 + a^2}{ab} = 2 + l^2 + \frac{l^4}{12} + \frac{l^6}{360} + \frac{l^8}{20160} + \text{&c.}$$

$$\frac{b^2 + a^2}{ab} - 2, \left(= \frac{b^2 - 2ba + a^2}{ab}\right) = l^2 + \frac{l^4}{12} + \frac{l^6}{360} + \frac{l^8}{20160} + \text{&c.}$$

This ſeries being divided by the ſeries $2l + \frac{l^3}{3} + \frac{l^5}{60} + \frac{l^7}{2520} +$ &c. the quote will be the ſeries, $\frac{l}{2} - \frac{l^3}{24} + \frac{l^5}{240} - \frac{17\,l^7}{40320} +$ &c.

Call

Call the ſum of this ſeries, s. Then, $\frac{b-a}{b+a}$ $(= \frac{b^2 - 2ba + a^2}{ab} \div \frac{b^2 - a^2}{ab}) = s \because b - a = sb + sa,\ b - sb = a + sa,\ b = \frac{1+s}{1-s}.\ a$, and $a = \frac{1-s}{1+s}.\ b$.

Here then we have a ſeries conſiſting of but half the number of terms of either of the ſeries firſt propoſed; but a diviſion is afterwards requiſite to find the natural number $\frac{b}{a}$, or $\frac{a}{b}$.

Let us endeavour to render this ſeries more convenient for practice and apply it to find the natural numbers of logarithms of any ſyſtem whatever, without the trouble of reducing the given logarithm to Napier's ſyſtem.——If we aſſume the firſt term for the whole ſeries, i. e. $\frac{l}{2} = s$; then will $\frac{b}{a} = \frac{1 + \frac{l}{2}}{1 - \frac{l}{2}}$ and $\frac{a}{b} = \frac{1 - \frac{l}{2}}{1 + \frac{l}{2}}$. making L to denote the logarithm of $\frac{b}{a}$ in any ſyſtem whatſoever,

whatſoever, ſince $\frac{L}{l} = p$, $\frac{L}{p} = l$; then by ſubſtitution, $\frac{b}{a} = \frac{2p+L}{2p-L}$ and $\frac{a}{b} = \frac{2p-L}{2p+L}$.

This abbreviation Dr. Halley has deduced from contracting into one two terms of the firſt ſeries.

If we unite the two firſt terms of the ſeries $\frac{l}{2} - \frac{l^3}{24} + \frac{l^5}{240} - \frac{17\,l^7}{40320} +$ &c. we may obtain a method ſtill more accurate, which however requires a ſecond operation; but yet perhaps may be preferable to the application of the ſeries in its original form.— The terms $\frac{l}{2}$ and $-\frac{l^3}{24}$ being reduced to a common denominator, their value is $\frac{12\,l - l^3}{24}$; which, by a proceſs ſimilar to that which has been uſed above, will appear to be equal to $\frac{6\,l}{12+l^2} - \frac{l^5}{288} + \frac{l^7}{3456} -$ &c. Then by ſubſtitution the ſeries becomes $\frac{6\,l}{12+l^2} + \frac{l^5}{1440} - \frac{l^7}{7560} +$ &c. It appears then, that the term $\frac{6\,l}{12+l^2}$ will more accurately repreſent the entire ſeries than the two terms $\frac{l}{2} - \frac{l^3}{24}$.

Assume

Assume $\frac{6l}{12+l^2} = s$. Then $\frac{b}{a}$ $(= \overline{1 + \frac{6l}{12+l^2}} \div \overline{1 - \frac{6l}{12+l^2}})$ $= \frac{12+6l+l^2}{12-6l+l^2}$; and $\frac{a}{b} = \frac{12-6l+l^2}{12+6l+l^2}$. In any syſtem whatſoever $\frac{b}{a} = \frac{12p^2+6pL+L^2}{12p^2-6pL+L^2}$ and $\frac{a}{b} = \frac{12p^2-6pL+L^2}{12p^2+6pL+L^2}$. Make $\frac{12p^2}{L} = q$; then $\frac{b}{a} = \frac{q+6p+L}{q-6p+L}$ and $\frac{a}{b} = \frac{q-6p+L}{q+6p+L}$.

The fraction $\frac{12+6l+l^2}{12-6l+l^2}$ thrown into a ſeries will be $1 + l + \frac{l^2}{2} + \frac{l^3}{6} + \frac{l^4}{24} + \frac{l^5}{144}$ + &c. ſo that the natural number correſponding to Napier's logarithm l will be accurately expreſſed thus $\frac{12+6l+l^2}{12-6l+l^2} + \frac{l^5}{720}$ + &c. Whence it appears that the fraction $\frac{12+6l+l^2}{12-6l+l^2}$ will more accurately expreſs the natural number of Napier's logarithm l, than the five firſt terms $(1 + l + \frac{l^2}{2} + \frac{l^3}{6} + \frac{l^4}{24})$ of the original ſeries. Now in the application of theſe terms to find the natural number of a logarithm, beſides reducing the given logarithm to Napier's ſyſtem if it be of any other, three multiplications are neceſſary, not to mention the diviſions

diviſions performed by ſmall diviſors. Whereas, to find the natural number $\frac{b}{a}$, by the application of the fraction $\frac{q+6p+L}{q-6p+L}$, or the natural number $\frac{a}{b}$, by the application of the fraction $\frac{q-6p+L}{q+6p+L}$, two diviſions are ſufficient, of whatever ſyſtem the logarithm may be. For $12p^2$ being given (ſince p is the modulus of the ſyſtem) q is found by one diviſion. Another diviſion will give the value of the fraction $\frac{q \mp 6p+L}{q \mp 6p+L}$, all its terms being known and of one dimenſion.

Since $\frac{b}{a} = \frac{q+6p+L}{q-6p+L}$ and $\frac{a}{b} = \frac{q-6p+L}{q+6p+L}$, we have $b = a + \frac{12pa}{q-6p+L}$ and $a = b - \frac{12pb}{q+6p+L}$.

Whence if a logarithm of any ſyſtem be given, to find its correſponding natural number; find the difference of the given logarithm and the neareſt logarithm to it (in the ſame ſyſtem) whoſe natural number is known. Call this difference L; the modulus of the ſyſtem p; and $\frac{12p}{L} = q$. Then, if the given

logarithm be the greater, its natural number will be the natural number of the aſſumed logarithm increaſed by the product of the ſame number into the fraction $\frac{12p}{q-6p+L}$; if leſs, its natural number will be the natural number of the aſſumed logarithm, diminiſhed by the product of the ſame number into the fraction $\frac{12p}{q+6p+L}$. This is not perfectly accurate; but will be a nearer approximation to the truth, the leſs the difference is of the given and the aſſumed logarithm.

CHRONOLOGICAL VIEW of the STATE of the WEATHER at DUBLIN in the Year 1797. By RICHARD KIRWAN, Esq; L.L.D. F.R.S. and M.R.I.A.

	BAROMETER.					THERMOMETER.			RAIN.		STORMS.	
1797.	Higheſt	Day it happened.	Loweſt.	Day it happened.	Mean of the Month.	Higheſt in the Day.	Loweſt at Night.	Mean of the Month.	Days.	Inches.	No.	Winds.
January - -	30.70	7th & 9th S E. S. & SW.	29.43	27th W.	30.156	54. –	26.50	42.86	19. on 1 of which fell ſnow.	1.57639	6	S by W. W. SW. & N.
February - -	30.72	9th & 10th S. to SW.	29.76	14th N. & NW.	30.406	56. –	28. –	43.57	8 on 1 of which fell ſnow.	–.315278	1	W. & NW.
March - -	30.56	21ſt E. to SW.	29.52	26th S.	30.062	54. –	31. –	41.95	14. on 2 of which fell ſnow.	1.930575	–	
April - -	30.38	9th NE.	29.45	3d NE. to E.	29 940	62. –	34. –	46.09	20. on 1 of which fell hail.	1.4712454	–	
May - -	30.40	23d SW. to to SE.	29.45	4th W. to N.	29 960	68. –	32.50	52.02	21. on 3 of which fell hail	1.8911668	–	
June - -	30.30	26th NW.	29.72	22d E.	30.490	69. –	40.50	54.72	19	–.893274	–	
July - -	30.65	30th E by N. to E by S.	29.74	31ſt W. & SW.	30.080	75. –	50. –	61.85	19	–.827604.	4	SW. & N.
Auguſt - -	30.42	22d & 23d W. & W by N.	29.55	18th S. to W.	30.260	72. –	50. –	59 96	23	4.926209	–	– 2 Days Thunder & Lightning.
September -	30.35	3d W. & NW.	29.38	20th W. & S.	29.840	64. –	48. –	56.81	16	2,390845	2	S. W. & N.
October - -	30.60	11th W. & W by N.	29.30	25th N.	30.030	63.50	30. –	50.61	18	3.15078	–	– 3 Nights very bluſtery.
November -	30 62	1ſt W. & NW.	29.50	22d & 30th N. NE. & E.	30 060	59. –	22. –	42.18	17. on 4 of which fell ſnow	2.679863	3	NE. N. W. & SW.
December - -	30.72	28th NW.	29.00	14th SW. to S.	29. 90	55.50	28. –	41.32	22	2.403994	8	S. W & N.
Mean of the Year	30,535		29.483		30 039			49.49	216. on 8 of which fell ſnow, & on 4 of which it hailed.	24 457224	24	Total No. of Storms in the Year.

POLITE LITERATURE.

Some HINTS *concerning the* STATE *of* SCIENCE *at the* REVIVAL *of* LETTERS, *grounded on a* PASSAGE *of* DANTE *in his* INFERNO, CANTO IV. v. 130.

By the Right Honourable the EARL *of* CHARLEMONT, *Preſident of the Royal Iriſh Academy and F. R. S.*

Read April 9th, 1796.

THIS earlieſt of modern Bards, who compoſed his excellent, though ſingular poem about the year 1300*, in deſcribing the Elyſium, prepared for the reception of thoſe Pagan worthies whoſe

 merits

* Dante was born, according to Boccaccio, in the year 1265, and probably wrote his Comedia at about the age of thirty-five years, a period of his life which many reaſons concur to make us ſuppoſe was honoured by this wonderful compoſition, and which well accords with what he himſelf ſays in the firſt line of his poem.

Nel mezzo del Cammin di noſtra Vita.

I have ſtyled Dante the earlieſt of modern Bards, and ſo he undoubtedly was of ſuch as have merited that illuſtrious appellation, though the Poeſia Provenzale began to be cultivated ſo early as in the year 1100, and though Italian poetry may be traced back to the year 1184—about ſixty years however it continued in its infant ſtate, and was firſt brought to a degree of maturity by Fra. Guittone D'Arezzo, who flouriſhed about the year 1250.

merits might have juſtly entitled them to a ſeat in Paradiſe, if they had partaken of the baptiſmal rite, mentions Ariſtotle as holding the firſt and principal place among the ancient philoſophers.

Poiche'nnalfai un poco piu la ciglia
Vidi 'l Maeſtro di *color che ſanno*
Seder tra Filoſofica Famiglia.
Tutti l'amiran, tutti onor gli fanno.
Quivi vid' io e Socrate, e Platone
Che 'nnanſi agli altri pui preſſo gli ſtanno.

My eyes a little raiſing, I deſcried
The ſov'reign maſter of all *thoſe who know*,
Sitting among the philoſophic race,
Admir'd by all, by all rever'd and honour'd:
There I beheld both Socrates and Plato,
Who prior to the reſt ſtand cloſe beſide him.

The character of Ariſtotle, which will bear the teſt of the moſt enlightened times, was peculiarly revered in the darker ages at the firſt Revival of Letters, and the praiſes laviſhed on this philoſopher approach almoſt to idolatry. His great Commentator, the Arabian Averroes, ſays of him that before Ariſtotle was born nature was yet incompleat, and that ſhe received from him the perfection of her being. The Theologians of Cologne held, that Ariſtotle was the precurſor of the Meſſiah in the myſteries of nature, as John the Baptiſt was in thoſe of Grace. Dante aſſigns him, in the paſſage here cited, the firſt place among Philoſophers, and cannot better ſhew his predilection than by preferring him to Socrates, and even to his maſter Plato, who are honoured by being placed next to him. Yet he does not venture ſo far as

Sepulveda,

Sepulveda, a learned Spaniard of the ſixteenth century, who, though an excellent, and, in all other points, an orthodox Catholick, publicly ſuſtained, and printed his opinion, that the ſoul of Ariſtotle was beatified in heaven.

We ſhall not be ſurpriſed at the prevalence of the Platonic and Ariſtotelian philoſophies in the more weſtern regions at the firſt dawn of literature, when we conſider that theſe were the faſhionable ſciences among the modern Greeks, who had refined upon their refinements, and rendered their obſcurity ſtill leſs intelligible, and that Conſtantinople was, in effect, the ſource from which learning flowed into Italy, the great reſervoir of knowledge, where it would naturally retain its original form and qualities; and this cauſe will appear ſtill more probable when we reflect that, though originally derived from the Greeks, it was brought into the weſtern parts of the world by the Arabians, who, in their conqueſt of the Aſiatic provinces had made themſelves acquainted with all the learning of Greece, and whoſe ſpeculative, ſubtle, and romantic genius, perfectly adapted to metaphyſical diſquiſition and to artificial dialectic, had eagerly ſeized, and adopted with a preference thoſe ſciences to which it was beſt ſuited. This ſpecies of erudition which they had found prevalent among the conquered Greeks, by their frequent incurſions into the weſtern regions, and principally by their ſettlements in Spain and Africa, they had diffuſed and eſtabliſhed among the unlettered inhabitants. Manuſcipts of all kinds they had in their victorious progreſs collected, and tranſlated with avidity; and that Ariſtotle in particular was, and long continued, their favourite author,

may

may be concluded from the *Gran Comento*, as Dante ſtyles it, written on his works by the Arabian Averroes * about half a century previous to the time of the poet.

The perpetual, violent, and trifling controverſies alſo, which long diſgraced the Chriſtian church, had introduced an ardent paſſion for diſpute, and a ſpirit of nice argumentation, and had prepared the minds of men to adopt and to admire the ſubtle and unintelligible jargon of the ſchools. Eager for victory in this war of words, Ariſtotle's logic was greedily ſtudied as an armour of defence, and a means of ſucceſsful controverſy; and the ſame ſpirit of nice diſcrimination exciting in the mind a love for what was difficult to be underſtood, and an ambition to be thought to comprehend what was ſcarcely intelligible, his philoſophy was revered in proportion to its obſcurity, and has conſequently obtained ſuch a ſanction and bigotted preference, that it ſtill remains, as it were by preſcription, the excluſive doctrine of almoſt all European ſeminaries †.

But,

* Averroes, or Averroys, died in the year 1206. I have ſtyled him *an Arabian*, and ſuch indeed he was by deſcent, though born at Cordova in Spain; from whence he migrated into the dominions of the king of Morocco, by whom he was invited to ſettle in his country, and was raiſed to offices of the higheſt dignity and importance.

† This was undoubtedly the fact not long ſince, and ſtill, I believe, continues to be true, particularly in Italy.

We are told by Voltaire, Eſſai ſur les Mœurs, &c. Tom. x. p. 222. 4to Edition: that ſo late as in the reign of Louis XIII. in or about the year 1624, the Parliament of Paris prohibited under pain of death the teaching any thing contrary to the doctrine of Ariſtotle, and that a perſon of the name *De Clave*, together with his aſſociates, was

But, beſides theſe accidental cauſes, we may perhaps find a reaſon for the preference given to this ſpecies of ſcience at the early approach of light, in the nature of the human mind, which, when emerging out of ignorance, is apt, at its firſt expanſion, to ſeize with avidity the more abſtruſe and refined parts of knowledge. Metaphyſical reſearches, and every ſpecies of nice, ſubtle, and

was baniſhed from Paris for having ſuſtained certain poſitions contrary to the principles of this favourite philoſopher on the number of the elements, and on matter and form. The ſame author, however, in a note on the third canto of his Pucelle, limits the penalty to that of the Gallies, which ſeems the more probable from the puniſhment of *De Clave*, who would ſcarcely have received ſo ſlight a ſentence as that of *baniſhment from Paris*, for a crime which the law had made liable to death.

For this marked preference given to the Ariſtotelian doctrine in all *Catholic* ſeminaries Bayle ſlyly aſſigns the following reaſon: ‘ Apres tout, il ne faut pas ‘ ſ'etonner que le Peripatetiſme, tel qu'on l'enſeigne depuis pluſieurs ſiecles, trouve ‘ tant de Protecteurs, et qu'on en croit les Interêts inſeparables de ceux de la ‘ Theologie; car il accoutume l'Eſprit a acquieſer ſans evidence. Cette Reunion ‘ d'interets doit etre aux Peripateticiens une gage de l'Immortalité de leur ſecte, ‘ et aux nouveaux Philoſophes un ſujet de diminuer leurs Eſperances.’

The glory of Ariſtotle ſuffered a ſhort eclipſe at the very beginning of the thirteenth century, when his metaphyſicks and phyſicks were prohibited from being read as favouring the errors of hereſy, but, having been commented upon, under the protection, as is ſuppoſed, of the Pope, by Albertus Magnus and Thomas Aquinas, it again ſhone forth with redoubled ſplendour.

To evince the eſteem in which this great philoſopher was held in the more enlightened times I ſhall here cite the weighty authorities of Grotius and of Eraſmus. The former in the Preface to his Book, De Jure Belli et Pacis, has theſe words, ‘ Inter ‘ Philoſophos meritò principem obtinet locum Ariſtoteles, ſive tractandi ordinem, ‘ ſive diſtinguendi acumen, ſive Rationum pondera conſideres.’ And Eraſmus, Epiſt. Lib. xxviii. Ep. 13. thus ſpeaks of him, ‘ Ariſtoteles Philoſophorum, ne Platone ‘ quidem juxta M. Tullium excepto, citra controverſiam, omnium doctiſſimus—Unus ‘ hic Philoſophiam, a diverſis per Fragmenta ſparſim mutilatimque traditam, in or- ‘ dinem redegit, ac veluti in Corpus compegit.’

and uſeleſs diſquiſition, ſeem to be preferred in the infancy of letters to the more ſolid and profitable ſciences, as the attention of children is captivated and fixed rather by ſupernatural and romantic tales than by ſober and uſeful hiſtory; and the ſubtleties of metaphyſicks will prevail among the half-enlightened in the ſame manner, and for the ſame reaſons, as the abſtruſe follies of magic and of aſtrology. When the mind firſt feels its powers, and finds itſelf aſſiſted and borne up by the wings of literature, it ſeems to think that it never can ſoar too high. Exulting in its newly diſcovered energy, it fondly ſuppoſes that nothing can arreſt its progreſs, ignorant as yet of thoſe impaſſable bounds which nature has ſet to its flight. The blind man, ſuddenly reſtored to ſight, would naturally firſt fix his eyes on the ſun as the moſt glorious object of contemplation, till experience ſhall have taught him that he is dazzled by its beams!

But if, in the infant dawn of learning, the mind is apt to baffle and loſe itſelf in theſe uſeleſs and preternatural excurſions, ſo do we alſo find it in the decline and decrepitude of letters. The ſtate of infancy and that of dotage are equally imbecile, and produce nearly the ſame effects.

Another cauſe of the early preference given to metaphyſical enquiry may perhaps concur with thoſe already mentioned. As the Being of a God is believed and acknowledged even by the moſt unlettered ſavages, it is no wonder that the nature of that Being, with whom all hopes and fears are intimately connected, ſhould

ſhould be the firſt object of intereſt to the expanding ſoul; and its own nature will certainly be the next object of its eager reſearches. —When we have once learned to think, it is moſt natural that we ſhould wiſh to know how and why we think. To ſatisfy its curioſity will be the firſt amuſement of the infant mind; and Science will therefore take place of Taſte, which, as it is only to be acquired by a nice and critical inveſtigation of beauties and of defects, muſt naturally await the ſlow progreſs of Study.

Such were moſt probably ſome, at leaſt, of the cauſes which, during the courſe of the thirteenth and fourteenth centuries, plunged and abſorbed the learned of Italy, the great teachers of the Weſt, in the unfathomable depths of ſcholaſtic ſpeculation and metaphyſical refinement, and, by prompting the mind to attempt the ſolution of invincible difficulty, baffled the efforts of the moſt penetrating genius, and checked the progreſs of uſeful knowledge. Hence proceeded that rage for abſtruſe diſquiſition, which, not content with rendering Proſe unintelligible, infected and obſcured even the pleaſant Region of Poetry, ſo as that ſcarce a Love-ſonnet could be given to the world unattended by the long, laborious, and perplexing comments of faſhionable Philoſophers— Hence was the ſtream of knowledge ſo far perverted and choaked in its courſe as to threaten with inundation thoſe fields it was meant to fertilize—Hence the dark allegories and myſtic theology of the learnedly-poetical Dante, and his beſt of imitators, Frezzi*—

*_Monſignor Frezzi Veſcovo de Foligno_ compoſed, between the years 1380 and 1400, the Quadriregio, an excellent Poem written in ſucceſsful imitation of Dante.—The merit of this very ancient and ſingular compoſition would entitle it to be better known by foreigners.

Hence were the early and preternatural abilities of Pico della Mirandola loſt to the benefit of mankind; and hence was Petrarch, the man of all others beſt adapted to the propagation of true Science, and who, even thus led aſtray, powerfully contributed to its advancement, bewildered in the flowery, but pathleſs, mazes of metaphyſical or platonic Love—yet all was perhaps for the beſt; and the mind, by exerciſing its powers in the inveſtigation, and eager purſuit of impoſſibilities, may probably have encreaſed its natural vigour, and have thus become more fit for beneficial enquiry; as the body, by having been early inured to exert its ſtrength in unprofitable efforts, is rendered more able for the real emolument of uſeful labour.

I HAVE ſaid, in the former part of this Eſſay, that *Conſtantinople was the ſource from which Learning flowed into Italy*; an aſſertion, which, though made in conformity with the opinion generally received, will require ſome explanation, as it is hazarded in apparent contradiction to the reſpectable authority of Voltaire, who, in his Eſſai ſur les Mœurs. Tom. ix. of his works, page 164. 4to edition, has theſe words, 'On fut redevable de toutes ces belles Nouveautes 'aux Toſcans—Ils firent tout renaitre *par leur ſeul Genie*, avant 'que le peu de ſcience qui etait reſtè a Conſtantinople refluat en 'Italie avec la Langue Grecque par les Conquetes des Ottomans— 'Florence etait alors une nouvelle Athenes, et parmi les Orateurs qui 'vinrent de la part des Villes d'Italie haranguer Boniface viii. ſur ſon 'Exaltation, on compta dix huit Florentins—On voit par la que 'ce n'eſt point aux Fugitifs de Conſtantinople qu'on a dû la Re-

'naiſſance

'naiſſance des Arts—Ces Grecs ne purent enſeigner aux Italiens 'que le Grec.'

THE ingenious author is certainly well founded in his aſſertion that Science and the Arts flouriſhed in Italy long before the loſs of their Imperial City had forced the Greeks to ſeek in the more Weſtern Countries an Aſylum, which their talents amply repaid to their generous Protectors; yet ſtill my poſition may be true, ſince the channel, through which I have ſuppoſed the Greek Learning to be conveyed, is totally different from that mentioned by Voltaire, and the time of ſuch influx greatly antecedent. Long before the taking of Conſtantinople had compelled theſe Sons of Science to ſeek elſewhere a refuge for that ſtudious and contemplative eaſe to which they were wholly addicted, their learning had, according to my idea, been propagated in Italy by means of the *Arabians*, whoſe conqueſts, and not thoſe of the *Turks*, were in reality the original ſource of Italian Literature, and Florence had already become *une nouvelle Athenes*, not merely *par le ſeul Genie des Florentins*, however brilliant that genius moſt certainly was, and how greatly ſoever it contributed to their literary acquirements, but from the fortunate importation of ſcientific materials, which brought it into action, and upon which it was enabled to operate. It muſt alſo be allowed that, whatever decay Science had experienced in its favourite clime, the general fund of Learning was in ſome degree increaſed by the acceſſion it received from the fugitive Greeks, and though the Greek Language was undoubtedly known and ſtudied in Italy long before it was taught there *par ces Fugitifs*, we may naturally ſuppoſe that, after their arrival, it was more

 generally

generally diffuſed, more methodically taught, and its utility augmented by a conſiderable addition to thoſe manuſcript treaſures of which Italy was already poſſeſſed. Neither is the advantage to be derived from a thorough knowledge of the Greek to be conſidered merely as the acceſſion of a new Language, but as the opening of a freſh and copious ſource of Science and of Taſte.—Indeed the language of the Greeks, and the importation of their books, may be conſidered as an advantage far greater than any which could reſult from the introduction of their beſt Teachers, ſince, however the latter might have degenerated, the former ſtill have remained, and ever will remain, the true ſtandard of Elegance.

REFLECTIONS *on the* CHOICE *of* SUBJECTS *for* TRAGEDY *among the* GREEK WRITERS. *By* WILLIAM PRESTON, *Esq. M.R.I.A.*

Read May 14th, 1796.

EVERY one who turns his thoughts on the Tragic Drama of the *Greeks*, the *Romans*, and early *Italian* Poets, (the two latter of which were no more than ſervile, and, in general, feeble imitators of the *Grecian* Drama) muſt be ſtruck with one particular—the extraordinary predominance of horror in the Fables of their Tragedy, which uniformly preſents us with the moſt dreadful and ſanguinary ſcenes, with miſeries of the deepeſt ſhade, and crimes, at which human nature ſtartles. *Furiis in ſcenis agitatus Oreſtes*—the horrid feaſt of *Atreus*—*Oedipus*, ſtained with inceſt, mangled by his own hands, and bleeding on the ſtage. The torments of *Hercules* in the invenomed robe—*Medea* * plunging the murderous poignard in the little boſoms of her innocent offſpring—The guilty paſſion of *Phedra*

* In *Euripides*, Medea does not abſolutely kill her children on the ſtage; but what is much more horrid, you hear the lamentable ſhrieks of the children.

Phedra for her ſtep-ſon,—Of *Canacé* for her brother—The luſtful cruelty of *Tereus*. Such were the favourite themes of the *Grecian* tragic muſe: I ſpeak not this in contempt; I feel all the veneration that the divine remains of ancient *Greece* muſt excite in a boſom ſmit with the love of poetry. If we except our immortal Shakeſpeare, what have all the efforts of ſo many ſucceeding centuries produced to emulate the ſublime productions of the *Athenian* tragic ſtage? In them we behold the mature and perfect form of tragedy; and thoſe, who, in modern days, have attempted to woo the Muſe of Tears, have proved either cold and languid imitators of the *Grecian* models, or, in venturing to depart from them, have disfigured and degraded the genuine form of tragedy. Yet, ſurely, we muſt allow that there is a ſtrange and uniform prevalence of the dreadful both in thoſe plays of the great tragedians which have been preſerved, and in fables of a vaſt number more, the names and ſubjects of which are recorded, though the pieces themſelves have periſhed.

An exhibition of the deepeſt horrors, with very few exceptions, in ſuch a prodigious number * of dramas, could not have proceeded from mere chance alone; it muſt have been produced by the deliberate choice of the writer. It may prove no unintereſting enquiry to endeavour to trace out the cauſes which led the Greek tragic writers to brood over the moſt ſombre images, and to range through

* Seven plays of Æſchylus are preſerved, the like number of Sophocles, nineteen of Euripides: the ſubjects of moſt of them are horrid.

through all the walks of hiſtory in queſt of ſubjects of horror and diſmay. On what principle, then, ſhall we explain this fact? Were the *Greeks* of a ferocious and cruel diſpoſition? Did they delight in ſcenes of blood? Did they ſuppoſe the frequency of ſuch enormous guilt as ſtruck the appalled ſpectator, from their ſtage, to be incident to human nature, and the repreſentation of it, to be a faithful picture of real life? Or again, did it require an exhibition of exaggerated miſery to melt their ſtern hearts, and draw from them the tears of ſympathy? I believe we may collect from hiſtory that there was, in truth, ſomething cruel and ferocious in the *Grecian* character; nor will it be difficult to point out certain circumſtances, the operation of which muſt neceſſarily have produced in a people ſuch diſpoſitions.

To begin with the mythology and religion of the *Greeks*, whether we conſider it as an efficient cauſe influencing the national character, or as an index to point out what that character was, we muſt ſuppoſe it adapted to their prevailing and popular notions, and accommodated to their reigning diſpoſitions and ſentiments. What were the *Grecian* divinities? Gods partial, changeful, paſſionate, unjuſt, whoſe attributes were rage, revenge and luſt.

What was the ferocious revenge of two of their moſt reſpectable and benevolent deities, on *Niobe* and her unoffending children? What was the ſtill more ferocious vengeance of *Apollo*, on the Satyr Marſyas? The Grecian mythology is crouded with ſimilar inſtances of cruelty. The religion which could circulate ſuch traditions

traditions of rage, revenge, and barbarity, concerning the Beings whoſe worſhip it inculcated, could not be the religion of a very mild or benign people; nor would its influence tend much to tranquillize the paſſions and ſoften the heart; or to infuſe a ſoftneſs and mildneſs into the national character.

THERE is no doubt that *Homer* copied faithfully the manners and ſentiments that were prevalent in his time, and exhibited his chiefs, acting and ſpeaking as leaders and warriors uſually did in his day. Judging, then, from the writings of *Homer*, of the characters and diſpoſitions of men when *Homer* wrote, it will appear that they were ferocious in no common degree. His heroes inſult, and triumph over their enemies in their dying moments, and kill the unarmed ſuppliant proſtrate at their feet; piracy was not only univerſally practiſed, but, even among the moſt dignified and reſpectable characters, the appellation of *Pirate* was conſidered as by no means reproachful; and men and women were daily carried off for the purpoſe of ſelling them as ſlaves. The conduct of *Achilles* towards the dead body of *Hector* does not excite the idea of general ferocity of manners, becauſe we are prepared for ſuch a conduct, and know that the poet meant to pourtray him. *Impiger*, *iracundus*, *inexorabilis acer*. But, when the pious and amiable *Telemachus*, and the good *Eumieus*, characters, which *Homer* wiſhed to exhibit in the moſt engaging colours, when they hang the female domeſtics, and mangle and mutilate the wretched *Melanthius* with their own

own hands, in a manner uncommonly ſavage. Whatever may have been the provocations of the prince and his family, and great they certainly were, the narrative, while it gives a ſtriking picture of ferocity, ſhews that the poet viewed it with approbation. The paſſage is too long and too horrid to be quoted here; the reader will find it in the twenty ſecond book of the Odyſſey.

Not to reſort to the doubtful hiſtory of the fabulous and heroic times, conſider the moſt dignified period of *Grecian* ſtory, when refinement and arts were in their zenith, and you will find the records of this people crowded with examples of ſanguinary cruelty. In the *Peloponneſian* war, the garriſon of *Platea*, a town which had deſerved ſo well of Greece, were, after a noble defence, deliberately brought forth by the Spartans and their allies, and put to death, one by one, in cold blood*. Quarter has been too often refuſed, in the heat of battle, by all people, antient and modern, but the Greeks generally murdered their priſoners of war, when all reſiſtance was paſt, and they wanted the excuſe of paſſion to palliate their cruelty. Thus, when *Mitylene* had ſurrendered on terms, the *Athenians*, in a full aſſembly of the people, and on debate, condemned all the males in the city (notwithſtanding the capitulation) to death, and all the females to ſlavery. This decree was revoked, it is true, on a ſecond debate, but it was the uncommon diligence alone of thoſe who conveyed the revocation, and performed their journey with aſtoniſhing celerity, that prevented its execution. However, all thoſe priſoners who had been ſent to

* Thucydides.

Tenedos, a thouſand in number, were tranſported to *Athens*, where they were all put to death, together with *Salethus*, the Spartan General †. When the *Athenians* reduced the rebellious city of *Scione*, on the Iſthmus of *Pallene*, all the males above the age of puberty were put to the ſword, and the women and children dragged into ſlavery ‡. The *Athenians*, too, having taken the capital of the iſland of *Melos*, after an obſtinate reſiſtance, all the males above fourteen years of age ſhared the ſame fate with the *Scioneans*. The women and children were condemned to perpetual ſervitude §. The *Corcyrean* ſeditions became proverbial, even among *Greeks*. They began in the murder of a popular leader, in the ſenate houſe, together with ſixty of his friends. Many of the democratic party were intimidated, and withdrew themſelves to *Athens*. The arrival of a *Corinthian* veſſel and a *Locedemonian* embaſſy encouraged the ariſtocracy to attempt the deſtruction of thoſe who remained. The attack was made in an hour of full aſſembly, and the ſtreets of *Corcyra* ſtreamed with blood. The ſlaves roſe, and reinforced the democratic party. Their numbers and fury, and the generous ardour of the women, rendered the cauſe of liberty victorious. The ariſtocratic party, vanquiſhed in turn, ſet fire to the ſurrounding houſes, to prevent a purſuit, and the moſt beautiful part of the city was deſtroyed in one night. While the conteſt raged, the altars, and the images of the gods, were ſurrounded by crowds of wretches, whom not even the terrors of a ſuperſtitious age could protect. The walls and pavements of the temples were bathed in blood. Many withdrew themſelves

† Thucydides. ‡ Thucydides. § Thucydides.

themſelves, by voluntary death, from the rage of their enemies. The *Spartans* and *Athenians*, mutually aſſiſting the parties with which they were connected, prolonged the fatal ſtruggle. At laſt the popular party decidedly prevailed, and, having got the whole body of their opponents into their power, threw them into a dungeon. From thence theſe unhappy people were dragged, in parties of twenty at a time, and compelled to paſs in pairs, their hands tied behind their backs, through two ranks of their enemies, armed with whips, prongs, and every inſtrument of diſgraceful torture. Thoſe who remained in priſon were a long time ignorant of the fate of their companions; but when they learned what was tranſacted without, they refuſed to quit their confinement, guarded the entrance, and, with one voice, called on the *Athenians* to kill them. Even this kind cruelty the *Athenians* refuſed to their prayers. The populace mounted the priſon walls, uncovered the roof, and overwhelmed thoſe below with ſtones, darts and arrows.

YET even this eventful ſcene of horrors we ſhall ſee ſurpaſſed, by the magnitude of the tragedy, the cruelty of the victors, and the acute and varied miſery of the vanquiſhed, when we turn to *Thucydides**, and peruſe his account of the diſaſtrous cloſe of the *Athenian* enterpriſe againſt *Syracuſe*; an account which no perſon of ſenſibility can read without a tear. I might multiply inſtances, without end; but the foregoing, ſurely, may juſtify my aſſertion, that a ſanguinary ſeverity prevailed in the national character of the *Greeks*.

* Lib. 7.

I AM aware that *Grecian* hiſtory has not commonly been conſidered in this point of view; ſo the foregoing remark, though an obvious one, may, to many, appear ſomewhat hazardous and novel. The *Greeks* were a glorious people! The ſtupendous monuments of their genius, in Poetry, Sculpture, and Architecture, which have triumphed over the ravages of time, inſpire us with implicit veneration, and ſo dazzle our eyes with their luſtre, that we are unable, or unwilling, to turn them on any harſh and barbarous circumſtance, any cruel and reproachful tranſaction, any thing calculated to diminiſh our admiration, I might almoſt ſay adoration—of beings who could thus write—ſpeak—and work; it is with pain that we endeavour to view the ſpots of the ſun—yet ſuch is the fact; and to this ſource muſt we trace the ſignal prevalence of the terrible and horrid, in *Tragedy*, as it firſt came from the hands of its *Grecian* inventors.

IT is obſervable too, that *Homer*, the venerable father of the Greek drama, as well as of the Epos, though he occaſionally ſhews himſelf a maſter of the ſoft, the tender, and amiable, chiefly delights, and moſt copiouſly abounds, in the grand, the awful, and the dreadful. Ancient tragedy, which did but draw his incidents into ſtage action, and reduce his ſpeeches into dialogue, muſt have taken much of its colouring, character, and ſpirit, from this prevailing tendency in its great archetype. " *Tu pater tu* " *rerum inventor.*"

IT will here be ſaid that we have remains of the Grecian ſculpture, which ſhew the moſt cultivated mind, the moſt refined

refined and delicate taſte. Every thing is chaſte and temperate, correct and beautiful; there appears nothing, to ſhew, that either the artiſt himſelf, or the models from which he wrought, could have been poſſeſſed by that ferocity of ſpirit, or animated by that cruel or ſanguinary diſpoſition, which I attribute to the *Grecian* moral character*. The *Apollo* of *Belvidere*, the *Medicean Venus*, the groupe of *Niobe* and her children, beſpeak minds governed by ſober judgment, awake to the fineſt feelings, and fertile in the faireſt ideas. The Greeks excelled no leſs in Painting than in Sculpture; and though, ages on ages have rolled away, ſince thoſe pictures, which were the admiration of antiquity, have been loſt to the world, a learned *Roman*, who poſſeſſed an exquiſite taſte for the fine arts, has left us a copious and moſt intereſting account of the principal *Grecian* painters and their works. From the details of the elder *Pliny*, it appears, that the ſubjects of the *Grecian* painting were, in general, as tender, ſoft, and engaging, as the ſubjects of their tragic drama were terrible and afflictive. Suppoſe all traces of the *Grecian* hiſtory and poetry annihilated, and that we knew and judged of them, only, by ſome of their ſtatues, and thoſe chapters in the thirty-fifth book of *Pliny* that relate to their painters; ſhould we heſitate to pronounce, from the ſweetneſs of the countenances, and the attitudes and characters of the figures, in what remains, and from the deſcriptions of what is loſt, that the *Greeks* were a people, not only of ſenſibility, but even of a mild and tender diſpoſition.

How

* To ſhew the correct judgment of *Grecian* artiſts, I have heard it obſerved that the figure of *Niobe*, in the famous groupe, has ſcarcely any breaſts, leſt an admixture of the luxurious

How can we reconcile the foregoing phenomena?—Painting and Sculpture, directly, as their chief object, exhibit the body; hiſtory and poetry, the actions, characters, and ſentiments of man. As, the ſtern and ferocious predominated, among the *Greeks*, in the latter, ſo the beautiful and the graceful, in an equal meaſure, prevailed in the former; and *Greece* was the peculiar region of fine forms. In fact, as we approximate to the eaſt, we ſeem to approach the favourite ſeats of Venus and the Graces; where human nature produces and rears her children, with a partial care, and diſtinguiſhed fondneſs.

The perſonal advantages, which the *Grecian* youth derived from nature, were heightened by art. The ſymmetry and ſtrength of the young men muſt have been improved, and the vigour and agility of their limbs encreaſed, by a conſtant uſe of the various exerciſes of the paleſtra, in which they were early initiated; and the young perſons of both ſexes were paſſionately addicted to the exerciſe of dancing, and generally excelled in it. All the claſſic writers, that have occaſion to allude to the *Grecian* manners and cuſtoms, take notice of the univerſal prevalence of this exerciſe in Greece. The dance is ſuppoſed to have been a component part of their theatrical repreſentations; it had a place, in many of their religious rites; and their very divinities, Diana and her Nymphs, were repreſented as dancing——

"Qualis aut Eurotæ ripis aut per juga Cynthi," &c.

These

luxurious and deſirable in a part ſhould counteract the effect in the whole; and diſcordant feelings be excited.

THESE dances were of a moſt varied and active kind, and muſt have contributed exceedingly to the graceful eaſe of the motions, and elegance of the attitudes of thoſe who practiſed them, and thus rendered them more happy ſubjects for the painter and the ſtatuary.

Is it too fanciful, to mention, as a ſource of external beauty, the extenſive uſe and powerful effects of muſic among the *Greeks*, who were attached to this divine art with an enthuſiaſtic love and devotion bordering on ſuperſtitious idolatry? their legiſlators and rulers, ſenſible of the quick and ardent temper, and ferocious diſpoſitions of the people, encouraged the univerſal fondneſs for muſic, regulated the national harmony by law, and endeavoured to diffuſe its practice and influence, as ſedatives of fiery humours, and correctives of turbulent and ungentle paſſions. *Milton*, who himſelf felt all the power of muſic, thus deſcribes its effects on the antient *Greeks*:

" ——— The Dorian mood,
" Of flutes and ſoft recorders, ſuch as rais'd
" To heighth of nobleſt temper heroes old
" Arming for battle, and inſtead of rage
" Delib'rate valour breath'd firm and unmov'd,
" With dread of death to flight or foul revolt.
" Nor wanting power to mitigate and 'ſuage
" With ſolemn touches troubled thought."

SUCH

Such being the power of muſic, to ſoothe and tranquillize the mind, it muſt have tended to diffuſe over the countenance an expreſſion of mild elevation and dignified compoſure, and to give noble and uncommon airs to the heads, ſuch as, in fact, are found in ſome of the countenances and buſts, that ſtill remain to us from the hand of *Grecian* ſculpture.

Thus, whereſoever the poet and hiſtorian turned their eyes, they ſaw the fierce, the turbulent and cruel, in the moral part of human nature, and ſketched their portraits accordingly, and adapted their productions to the taſte of their readers or auditors: Far different was the caſe of the ſculptor and the painter; with them all was delight and rapture; from the corporeal part of human nature, the faireſt ideas of beauty and grace beamed inceſſantly on their enchanted eyes.

As a further demonſtration of the ferocious character of the *Greeks*, I ſhall mention here, though not preciſely in its right place, an obſervation, which I ought to have made before, that the practice of expoſing and deſtroying new-born infants was very general among them; and, however cruel in itſelf, was not marked with infamy, or conſidered as including in it any degree of moral turpitude. To convince us of this fact, we need not reſort farther than to the comedies of *Terence*, who, we know, was a cloſe imitator of *Menander*, or rather, indeed, it is to be ſuppoſed, that the comedies of the former were literal tranſlations from thoſe of the latter. *Terence*, then, muſt be conſidered

ſidered as giving us a faithful picture of *Grecian* manners; and we find him ſpeaking of the expoſure of a new-born infant, as a meaſure of prudence—a laudable arrangement of domeſtic œconomy:

" Audire eſt operæ pretium eorum audaciam,
" Nam inceptio eſt amentium—haud amantium,
" Quidquid peperiſſet decreverunt tollere.

ANDRIA.

" *So.* Meminiſtin' me eſſe gravidam, & mîhi te maxumopere
" dicere,
" Si puellam parerem, nolle tolli? *Chr.* Scio quid feceris;
" Suſtuliſti."

HEAUTONTIMORUMENOS.

HAVING, thus, eſtabliſhed the fact, of an exiſting ferocity in the character of the *Greeks*, let me, in the next place, endeavour to point out, briefly, whence this diſpoſition aroſe. We ſhall readily trace its origin; if we conſider the manner, in which *Greece* was originally peopled, by the ſucceſſive irruptions of migrating hordes. In very early times many different people, of whom the Greek writers, in the moſt enlightened ages, could give no ſatisfactory account, over-ran *Greece*; ſometimes mixing with the antient inhabitants, ſometimes expelling them. Of the expelled, ſome wandered in queſt of unoccupied vales, or, in their turn, drove out the inhabitants of the firſt country, that lay expoſed to them, if they proved weaker than themſelves. Others retired to the neighbouring mountains, and thence, harraſſing the in-

truders, not unfrequently recovered, in time, their old poſſeſſions *. Thus was *Greece*, in its early periods, in a ſtate of perpetual outrage and piratical warfare. The moſt powerful incentives, indeed, were offered to piracy, in a ſea whoſe innumerable iſlands and ports afforded ſingular opportunity and convenience for the practice; and, in fact, the eſtimation of piracy, as an honourable practice, long prevailed among the *Greeks*. *Thucydides* obſerves, that before the reign of *Minos* (who fitted out a fleet, and exerted himſelf, to clear the ſeas of plunderers and depredators) all the ſhores, both of the Continent and the iſlands of *Greece*, were nearly deſerted; the ground was cultivated only at a ſecure diſtance from the ſea; and there, only, towns and villages were to be found.

When ſomething of civilization, and more ſettled forms of government, took place in *Greece*, it was divided into a vaſt number of ſmall ſtates or kingdoms, all inſpired with a degree of jealouſy and rivalſhip; all poſſeſſed with mutual hatred and animoſity; and all engaged in perpetual hoſtilities againſt each other. Theſe inveterate contentions, which were diffuſed over the whole face of the country, and produced a variety of cruel and ſanguinary ſcenes, muſt have excited ferocious diſpoſitions in the boſoms of the *Greeks*, and formed them to a certain ſeverity of character. Theſe accidental circumſtances, in their ſituation, which prediſpoſed them to pay a particular attention to military inſtitutions

* See the beginning of the firſt book of Thucydides.

inſtitutions, and martial exerciſes, and muſt have made the love of arms general, and the character of a ſoldier a favourite one, introduced a mode of education, which, of courſe, augmented and perpetuated the ſeverity of character.

THIS was not only the ſituation of *Greece*, in what are called her heroic times, in other words, in her age of barbariſm, but was literally the caſe, in the moſt poliſhed and reſpectable æra of her ſtory. The ſmall monarchies were gradually overthrown, but the country ſtill remained in its ſtate of diviſion, and was portioned out, into a variety of ſmall republics, moſt of them *Democracies*, eſtabliſhed on the ruins of the Monarchies. *Athens*, in particular, which took a diſtinguiſhed lead, in literature, eloquence, and the fine arts, and gave the *ton* to the taſte of *Greece*, was purely democratic. The prevalence of democracy, therefore, may be pointed out as another powerful ſource of ſeverity of character; for this form of government inceſſantly feeds the pride of the individual. As a component part of the ſupreme majeſty of the people, the ſimple citizen is perpetually flattered, by the homage of the orator and the poet *. He is the ſupreme maker and expounder of the laws, the arbiter of peace and war, the diſpenſer of power and honours. He ſees generals and ſtateſmen proſtrate at his feet. The luſt of domination inflames his head; the poſſeſſion of power hardens his heart; all

* We find many of their ſubjects were ſelected by the Dramatic Poets on purpoſe to pay a compliment to the Athenian people.—Oedipus Coloneus, for example.

the boiſterous and ſtormy paſſions are called into exerciſe, and this, in ſo much the higher degree, as the ſtate of which he is a member is narrow and ſmall, and the ſphere of his activity confined. A democracy may exclude luxury, and favour a ſimplicity of manners; it may cheriſh the ſtern republican virtues, and maintain a rigid inflexible character; but it is certainly unfavourable to the ſoft unbendings of domeſtic life, to the tender ſympathies and mild affections of humanity.

THUS have I endeavoured to point out ſome of the cauſes, which produced in the *Greek* tragic writers a predilection for ſubjects in which the *horrible* ſo violently predominates. And here I might diſmiſs my ſubject, with a remark, that the hiſtory of nations, their forms of government and cuſtoms, are not as much conſidered, as they deſerve to be, by thoſe who undertake to criticiſe their writers: but two queſtions ariſe ſo naturally out of this diſquiſition, that I cannot forbear the beſtowing on them a few lines.

THERE were, as we ſee, cauſes peculiar to themſelves that led the *Greeks* to a predilection for ſubjects of horror, and a marked ſelection of them, as the foundation of their dramas: but why do we, in theſe days of morbid ſoftneſs, when the affectation of humanity is carried to an exceſs, under the denomination of ſentiment; why do we receive pleaſure, from the peruſal of tales of horror, and the repreſentation on the ſtage of fables, like *Macbeth*, in which the terrible is predominant?—

And

And is the pleaſure thus excited conformable to the precepts of ſtrict morality, and reconcileable with the intereſts of humanity? The ſame queſtions are applicable to the pleaſure we feel in the contemplation of ſuch objects as the *Laocoon* and dying gladiator in ſculpture, and (if I may mention them without lightneſs in the ſame ſentence) of the ſacred and dreadful ſubjects of modern painting. The martyrdom of ſaints, and terrors of a crucifixion.

Is it, that pleaſure and pain, not only ſo blend and meet, that frequently, we know not preciſely, where the one begins, and the other ends, but, that the pre-exiſtence of a certain degree of pain ſeems requiſite, to give a poignancy to pleaſure, and pre-diſpoſes the ſenſes, by contraſt, to feel the whole force of grateful objects? ſome of the moſt exquiſite ſtrains of muſic are produced, by notes that run into an artificial diſcord; reſt is doubly pleaſing after labour; preceding hunger is neceſſary to make us enjoy food with a full reliſh. An effect ſomewhat analogous may take place, when the tale of woe, or the tragic repreſentations on the ſtage, harrows up the ſoul. The repreſentation, however diſtreſsful, is ſtill a repreſentation. We inſtantly recollect that the ſcene is fictitious: and this recollection not only abates our uneaſineſs, but diffuſes a ſecret joy on the mind; a joy the more ſenſibly felt on account of the painful emotion, that inſtantaneouſly preceded it, with bounds of ſeparation ſcarce diſcernible.

But are there, in reality, any bounds of ſeparation? Have not the uneaſy paſſions, even in the very time that we are diſtreſſed by

by them; and although the occaſions are inſtant and real, a ſecret complacency mixed with them? Man contemplates his own exiſtence with a conſcious pride and ſelf-complacency; every act that aſſures him of his being, and of his powers, is a ſource of ſecret exultation. The exerciſe of the limbs not only contributes to preſerve the health of the body, but is attended by a degree of pleaſure and exhiliration of the ſpirits. Conformably to a like order of nature, every exerciſe of the faculties of the mind, every exertion of the ſentient principle, is accompanied by agreeable ſenſations. The acquiſition of knowledge, the exerciſe of ſympathy, of fortitude, of ſagacity, acts of benevolence, of generoſity and ſelf-denial (independent of the teſtimony of approving conſcience,) bring with them an internal ſatisfaction. What is more ſtrange, even the ungentle and criminal paſſions have a certain unhappy pleaſure, a diſeaſed and ſickly pleaſure, indeed, appropriated to their activity.

Man being deſigned, by his Maker, for active functions, this pleaſure neceſſarily and inſeparably connected with the exerciſe of his powers, and the accompliſhment of the ends of his creation, ſhews the wiſdom of Him, who moulded his corporeal frame, and infuſed into it the animating ſpirit. As exerciſes of ſtrength and agility are productive of pleaſure to the robuſt and healthy, and contribute to preſerve the ſtrength and vigour of the body, exertions of memory, reflection, and ratiocination are, at once, a ſource of mental enjoyment, and a preſervative of mental ſanity: and thus did He, who has beautified and ennobled all creation with the means and forms of pleaſure, kindly ordain

and

and provide that an inert ſtate ſhould be irkſome and unfriendly both to the body and mind; activity, merely and ſimply as ſuch, a ſource of enjoyment and vigour to both.

The habitual exerciſe of his powers being thus congenial to to man, and eſſential to the well-being both of the individual and of ſociety, it is to be obſerved that tragical incidents moſt powerfully tend to excite the activity of the mind, by calling forth the various emotions of fear, pity, ſurpriſe, indignation and ſorrow. The magic power of fiction places us in ſituations more affecting and intereſting, more fraught with energies of the ſoul, than thoſe which commonly preſent themſelves in the calm and level current of private life and domeſtic occurrences, where the viciſſitudes of fortune are leſs rapid, and the exceſſes of guilt and virtue are equally rare with the extremities of miſery or happineſs.

From whence does deep play derive its faſcinating power? Are we to attribute the ſpirit of gaming to avarice? far from it; many of the perſons who are moſt ſtrongly poſſeſſed and infatuated by this propenſity, ſhew, on other occaſions, a total diſregard of money. The ſudden viciſſitudes of fortune, the hopes and fears attendant on deep play, occupy the mind, fill it with agitation in which it delights, and baniſh that dead calm of fixed repoſe which is ſo burthenſome and oppreſſive to our nature.

Why do ſuch numbers croud to an execution? Is it from a ſpirit of inherent cruelty that prompts the ſpectators to view with

with pleaſure the death or torture of their fellow-creatures? by no means. Women, and young perſons, whoſe natures are commonly ſoft and compaſſionate, run with as much avidity as the reſt on thoſe occaſions; and, however great may be the guilt of the ſufferer, pity is the paſſion moſt generally prevalent in the boſoms of the multitude. Curioſity, and ſtill more the ardent deſire of having their feelings excited, are the incentives that drive the croud to thoſe ſcenes of death and ſorrow.

The *Romans* were by no means a cruel people. Freemen were exempted from capital puniſhment by their law; many inſtances of clemency, and national mildneſs of character, occur in the courſe of their hiſtory; yet they delighted to an extravagant degree in the combats of gladiators, and the ſanguinary ſpectacles of the Arena. Whence did this proceed? The *Romans* had lively paſſions, and great ſenſibility; and ſuch was the pleaſure they experienced from their feelings being rouſed and called into action, that the horror and cruelty of the ſpectacle were withdrawn from view, and loſt in the eager curioſity and intent activity of the moment. We may trace to the ſame ſource the fondneſs of the *Portugueſe* and *Spaniards* for their Bull-Fights.

Independent of the concomitant pleaſure and ſelf-congratulation connected with the activity of man, merely as activity, a peculiar charm and ſweetneſs are attached to the exerciſe of all our ſocial affections. While the philanthropiſt laments the miſery of his friends, his country, the human race, and unable to relieve, beſtows on miſery—*all he has*, a *tear*;—He yet rejoices in the generous

generous diſpoſition, and feels a ſatisfaction, ſuperior to all that reſults from the moſt indulged voluptuouſneſs. So engaging are the ſympathetic feelings, and ſuch the power of conſcious reflection, to brighten up the face of ſorrow; that, as Dr. *Hurd* * juſtly obſerves, it ſeems, that Providence, in compaſſion to human feelings, had, together with our ſorrows, infuſed a kind of balm into the mind, to temper and qualify, as it were, theſe bitter ingredients.

I PROCEED, now, to the other queſtion. I have heard it aſſerted that epic or dramatic productions on ſubjects in which the horrible or atrocious is eminently predominant, ſhould be reprobated, as a perverſion of the powers of poetry, unfavourable to the true intereſts of morality, and to the improvement of the human mind. The advocates for this opinion contend that ſuch narratives will, moſt probably, diſguſt, or, at leaſt, fail to pleaſe the refined and judicious readers; and if it ſhould happen to produce pleaſure, that pleaſure muſt, in ſome degree, proceed from, or be accompanied by criminal, or at leaſt unamiable emotions; and, frequently indulged, muſt tend to make the nature ferocious. The mind, familiarized with horrors, will gradually loſe its natural deteſtation of cruelty, and become hardened in ferocity, by a recurrence of ſentiments, and a repetition of ſpectacles, that outrage every tender feeling. Subjects of this kind ſhould be covered with a veil, and conſigned to eternal oblivion; inſtead of

* Notes on Horace.

their being uſhered to public notice, adorned with all the colouring of genius, and cloathed in the faſcinating garb of poetry. There are crimes and enormities of which it ſhould not be ſo much as ſuppoſed that our nature is capable.

THERE is ſomething plauſible in the objection which I have ſtated; but it may be urged, in reply, that no repreſentation of criminality or vice, is, in itſelf, and abſtractedly conſidered, immoral; it becomes ſo by its relations to ſociety, and from a conſideration of its pernicious tendency, and probable effects; from its being calculated to deprave and taint the mind, and produce an imitation of what it exhibits. To do this the features of vice muſt be ſoftened, the portrait muſt be flattering. What flattering portrait can there be of genuine and total deformity? It muſt, indeed, require more than ordinary addreſs to make men in love with horrors. The more atrocious and monſtrous the crime, the more difficult it will be to paint it in alluring colours. Of all the ſubjects of poetry, and the other imitative arts, the horrible and ferocious ſtand moſt perfectly clear of any tendency to pervert the mind. The brutal and ſavage paſſions which produce the moſt dreadful tragic ſcenes, ſo torture the guilty boſom, that harbours them, that the criminality, which they prompt, is inſeparable from its own obvious and immediate puniſhment.

THE repreſentation of paſſions leading to immediate torment of their ſubject, and exciting horror and deteſtation in the witneſſes

neſſes of their operation, can poſſeſs but ſmall powers of ſeduction: they are thoſe vices that tend to momentary gratification; they are thoſe illicit paſſions which are remotely allied, or faintly ſimilar, to virtuous emotions, (as luſt to love, pride to magnanimity, ferocity to courage, profuſion to generoſity) that are capable of being repreſented in alluring colours, and poſſeſs an unhappy power of faſcination; and it is only the exhibition of ſuch emotions, and their operation, that can be injurious to the intereſts of morality, and, of courſe, criminal in the writer or the artiſt. The reſemblance, at firſt ſight, to virtues, deceives the unwary mind, and tends to confuſe the notions of right and wrong; to eraſe the bounds and diviſions between vice and virtue. The dazzling portraits of ſeducing objects, and luxurious pleaſures, blind the judgment, and fill the heated imagination with impure images. The popular applauſes, and the pleaſures that ſometimes accompany vice and guilt, are immediately preſent; their miſchievous conſequences, the future pain, remorſe and calamity, to which they lead, are remote, and concealed from view.

It is ſaid that a frequent repetition of ſuch terrible ſubjects as were not only repreſented frequently on the *Grecian* ſtage, but were its peculiar favourites, may familiarize the mind with ſcenes of horror, and leſſen its natural tenderneſs and ſimilarity. No: there is no danger that outrageous and cruel paſſions ſhould become contagious. In *their* repreſentation the poiſon will carry with it its own antidote. The acute feelings, the dreadful ca-

 taſtrophes,

taſtrophes, the univerſal fear and abhorrence that purſue the guilty monſters of the tragic ſtage, prevent their ſentiments from ſpreading infection, and their examples from exciting imitation. Though the *Grecian* Muſe delighted in the exhibition of outrageous paſſions and enormous guilt, ſhe gave them no falſe colouring. She delighted to repreſent them, as they truly were, objects of horror, and cauſes of miſery; not as themes of approbation, much leſs as ſubjects of imitation. The powers of eloquence and poetry were employed, in heightening their natural aptitude to excite abhorrence, and in ſhowing their fatal conſequences, not in a wild attempt, to decorate or make them plauſible; for the extravagant and bombaſtic fury of the *German* ſtage was reſerved the mad and miſchievous deſign, of palliating, or embelliſhing, what ought to excite diſguſt and horror, and of cloathing rapine, impiety, and aſſaſſination, in a ſplendid and impoſing garb: Vain and criminal attempt! Yet ſuch is the tendency of the *Robbers* of *Schiller*, a performance which deſerves equal reprobation, from ſound taſte, and from ſound morality.

A SMALL degree of reflection may convince us, that no habits of cruelty can be imbibed, no mechanical hardneſs of heart be contracted, by the peruſal of works that relate theſe dreadful ſtories in queſtion; or from the being preſent at repreſentations of gigantic villainy, or ſtupendous miſery, on the ſtage. It is wiſely ordained by the Author of our nature, in order to deter man from the commiſſion of acts of cruelty, that ſuch acts not only ſtrike the moral ſenſe with a perception of their turpitude, but

but are alſo accompanied with circumſtances that violently offend and grate on the exterior ſenſes with ſomething hideous and diſguſting. The ſight of a wounded and mangled body, the ſcreams and groans of a wretch enduring torture, from any cauſe, whether accidental or deſigned, are painful to the eyes and ears; intolerably ſo to thoſe of moſt men. They produce a loathing and nauſea, and even ſometimes cauſe perſons, not habituated to ſuch ſights and ſounds, to ſwoon away *. Such ſpectacles, however, by a frequent repetition, loſe much of their horror. Phyſical cauſes, by repeated action, loſe their efficacy; it is quite the reverſe with reſpect to moral cauſes. The ſenſes become habituated to objects that, at firſt, offend them; and the diſagreeable phyſical effects of ſuch objects become leſs and leſs violent. Perſons in the army, whoſe duty frequently leads them to be preſent at military executions, will be very ſenſible of the truth of this obſervation.

When cruel acts and ſubjects of acute and agonizing miſery are repreſented, through the medium of the imitative arts, the caſe is far different; on thoſe occaſions, there is always a perception, or perſuaſion, that the exhibition is not real. *That* perception ſteps in to our relief, in the moment of diſtreſs, and forms part of the pleaſure, we experience at the repreſentation of a tragedy. At the real ſpectacle of cruelty the

* Such was the effect of ſeeing two Negros burned in Jamaica on a perſon who deſcribed his feelings to me.

the mind muſt meet the dreadful certainty; and muſt harden itſelf, by an effort, to encounter it. This effort, often repeated, and accompanied with encreaſed firmneſs of nerves, may, at length, degenerate into habits of cruelty. Beſides, the repreſentation is always leſs vivid than the reality. Strong enough it may be, to produce a momentary deluſion, and excite terror and pity; but not ſtrong enough, either, to overwhelm the ſpirit, or to harden the nature. Though we are ſtruck with horror, and melted into tears, at the repreſentation of a murder, on the ſtage, we do not feel the ſame phyſical effects; we do not tremble, and perceive a ſickneſs, a cold ſweat, perhaps a faintneſs; whereas, a perſon unuſed to ſcenes of cruelty would moſt probably experience theſe inconveniencies; were he to ſee a perſon ſtabbed beſide him, and falling at his feet; were he to hear his dying groan, or be ſprinkled with his blood.

Wherein conſiſts the true difference? In the real cataſtrophe, the different ſenſes, ſight, hearing, touch, all concur in bearing teſtimony to each other, and aſcertain the dreadful certainty beyond a poſſibility of doubt. Where the imitative arts repreſent any ſingle action, or ſeries of actions, there is not the mutual ſuffrage, or reciprocal corroboration. Poetry and hiſtory imitate actions and objects, by a very indirect agency of the ſenſe of ſeeing, preſenting to us words, which recall the ideas of what we have ſeen and known; to which medium of words, as ſigns of ideas, the force of articulate ſounds is added, when compoſitions are read aloud or recited. Painting imitates, through the

the medium of ſight directly, and of ſight alone: ſo does ſculpture alſo, unleſs we admit the touch, to which ſculpture, as an imitative art, may be ſaid to appeal, in ſome faint degree; as for inſtance, a blind man, by handling an exquiſite ſtatue, may form ideas of ſymmetry, grace and beauty. Muſic, which, in a ſmall degree, is an imitative art, is confined to the ſenſe of hearing. As to the repreſentations of the theatre, which carry the deluſions of the imitative arts as far as they will go, they are confined, to the ſight and hearing, and want the ſuffrage of the touch. Thus, we find, in every one of the imitative arts, there is a deficiency of teſtimony, a certain link of the chain of evidence, that invariably accompanies the reality of exiſtence, is ever wanting.

I FIND I have, unawares, been betrayed into a degree of prolixity, of which I little dreamed; and, at the ſame time, I fear, that I have but imperfectly expreſſed my meaning, and failed of attaining that fullneſs and preciſion, which the ſubject deſerves. I know not well how to excuſe my raſhneſs, in preſuming to obtrude this haſty ſketch on the Academy; and, I truſt, that the candour of my readers will aſcribe this temerity to the true cauſe—a wiſh to amuſe them, at a vacant hour, and not to any diſregard of their judgment.

An ESSAY *on the* VARIATIONS *of* ENGLISH PROSE, *from the* REVOLUTION *to the* PRESENT TIME. *By* THOMAS WALLACE, *A. B. and M. R. I. A.; to which was adjudged the Gold Prize Medal propoſed by the Royal Iriſh Academy for the beſt Eſſay on that Subject.*

Ut ſilvæ foliis pronos mutantur in annos;
Prima cadunt: ita verborum vetus interit ætas,
Et, juvenum ritu, florent modo nata, vigentque.

HORACE.

Read June 18, 1796

THE progreſs of language marks the progreſs of the human mind. They proceed together with equal ſtep from the rudeneſs of barbariſm toward that ſtate beyond which improvement cannot go, in which language exhibits the higheſt poliſh of elegance and accuracy, and the mind exerts all its faculties in their full force. So true is this, that there can ſcarcely be found any period in the hiſtory of any people when the ſtate of their language did not accurately correſpond with the ſtate of their polity and manners, and when a ſagacious obſerver might not have aſcertained, with tolerable exactneſs, the excellence and refinement of theſe from the qualities of their literary productions. Hence the inveſtigations of the philologiſt become uſeful as they furniſh important aids

to the reſearches of the hiſtorian, and the ſpeculations of the moraliſt.

To this general rule there is, however, one exception. Long before the manners of the Greeks had reached that refinement, or their polity had been matured to that perfection which conſtitute a nation highly civilized, their language had become copious, energetic and correct. In the compoſitions of Homer we find, perhaps, as much ſtrength, harmony and expreſſion, as in thoſe of any ſubſequent Greek writer; and yet unqueſtionably, in Homer's day, Greece had made no very conſiderable approaches towards excellence in the arts, ſkill in government, or refinement in manners.

But if in Greece we find an exception to the rule which marks on the ſcale of language the improvement of the national mind, in modern Europe we meet abundant illuſtration of its truth. Here, it will be found, that until ſettled government, founded on permanent ſyſtem, ſucceeded the fluctuations of deſpotiſm or anarchy, and, inſtead of the ferocious and whimſical manners of the middle ages, introduced the milder and more rational habits of modern times, until, in a word, the light of philoſophy ſhone in our horizon, and ſcattered the thick darkneſs which hung around the human intellect, the language of every people in Europe correſponded in coarſeneſs and confuſion with their modes of life and of thinking. Of this England herſelf is perhaps the moſt ſtriking inſtance. With a conſtitution which vibrated long between oppoſite extremes before it finally ſettled in the middle

point

point where liberty as well as truth is found, the moral character of her people was vague and changeful. Agitated long by civil conteſts, and depreſſed by the barbarous and deteriorating principles of the feudal policy, the human mind could not, and in fact did not, until a very late period, emerge from that deep groſſneſs into which by thoſe cauſes it had been ſunk. The language of England during thoſe times correſponded with her circumſtances. Rude and anomalous, at once ſuperfluous and deficient, it was equally a ſtranger to preciſion and to grace: fixed by no ſtandard, though it abounded in words, it was yet, becauſe thoſe words were vaguely uſed, incapable of expreſſing with accuracy any nice complication of thought. While men were unaccuſtomed to think with preciſion on moral topics, the whole claſs of moral terms muſt have been of changeful and indeterminate meaning; and while theſe topics were not the *frequent* ſubjects of living ſpeech or written diſcourſes, thoſe few but important words which are uſed, not to deſignate things, but to exhibit the various poſitions of the mind in thinking, to ſhew the relation which it means to eſtabliſh between two propoſitions, or the different parts of the ſame propoſition, muſt have been awkwardly and often improperly uſed. Such a ſtate of language could have exiſted only where taſte was yet unknown, and the powers of the human mind yet uncultivated.

Two cauſes contributed to raiſe the Engliſh language from this degraded ſtate. Firſt the Reformation, which by obtruding on the attention moral ſubjects of the moſt momentous concern, made it in ſome meaſure neceſſary for men to think with more

 preciſion

preciſion and cloſeneſs: Secondly, the ſubſequent diſputes between the crown and people on the limits of prerogative and popular right, which continued from the time of Elizabeth to the revolution, and which corroborated into habit that mode of cloſer and more abſtract thinking which the Reformation had introduced. According to the theory we have adopted this change ſhould have induced an improvement in ſtyle: it did ſo; the Engliſh language roſe rapidly from the low ſtate in which it ſtood in the beginning of the reign of Henry the Eighth, until, at the acceſſion of William the Third, it had acquired a diſtinguiſhed degree of excellence. This excellence, however, was but comparative, and appears rather when we conſider its former defects, than its ſubſequent improvements; for, from the time of the Revolution to the preſent day, a numerous ſucceſſion of fine writers have laboured with ſucceſs to add to its elegance, copiouſneſs and ſtrength. What they have done, and how far they have raiſed the Engliſh language above its former humble level, will be beſt known by conſidering the variations of ſtyle which, within that period, it has undergone.

In order to give a hiſtory of theſe variations it is not neceſſary to engage in a diſſertation on the ſtyle of every author of character who has written within the period which we conſider; nor indeed would ſuch a work be practicable within the limits of a ſhort eſſay: it will anſwer the end at which we aim to point out the general characteriſtics which have ſucceſſively diſtinguiſhed the ſtyle of Engliſh proſe within that time without engaging in a minute deſcription of the peculiarities of individual writers, except

thoſe

thoſe by whom remarkable variations have been introduced, and whoſe diſtinguiſhed excellence has procured for thoſe variations a general adoption. Even this taſk, however, though leſs laborious and leſs prolix than the other, is not without its difficulty. Between the coarſe homelineſs of Burnet and the elaborate poliſh of Gibbon; between the looſe and uneven compoſition of Tillotſon, in which the ray of genius is ſo often obſcured by the medium through which it paſſes, and the cloſe preciſion of Johnſon, through which the bright idea ſhines with ſteady luſtre (if, indeed, it does not from the expreſſion itſelf derive much of that luſtre) the difference is great indeed, and to perceive it requires but little exertion of critical diſcernment. But other writers have varied eſſentially the ſtyle of Engliſh proſe between whoſe reſpective merits the difference is neither ſo great nor ſo obvious: here lies the difficulty. The difference of oppoſite colours is eaſily ſeen, and not difficult to be deſcribed; but of the variety of mixing tints which lie between the two extremes to mark with accuracy the points of tranſition; to catch the almoſt evaneſcent diſtinctions between collateral ſhades, and exhibit them with truth and ſteadineſs to the eye, is a work for which talents leſs common are neceſſary.

Though previous to the Revolution the ſtyle of Engliſh proſe had been greatly improved, it was notwithſtanding very far from being faultleſs. Scarcely any ſingle epithet, indeed, can be found to deſcribe its errors. It was looſe, negligent, capricious, and inaccurate: the periods were long and complicated; their parts clumſily connected; circumſtances which were neceſſary to be introduced

introduced into a ſentence were generally placed injudiciouſly; and in many inſtances clauſes were appended which ſhould have been formed into diſtinct ſentences. Even of thoſe writers who ranked higheſt for compoſition, the greater number abounded in ſynonymes, a ſure mark, not merely of negligent compoſition, but of looſe and inaccurate habits of thought. In the ſelection of words they were either negligent or unſkilful, for, in a multitude of inſtances, of two words which ſeemed to court choice, they choſe that which, by verging on burleſque, tended to degrade the ſubject, rather than that which would have ſuited its dignity. In metaphor they were copious; but their metaphors partook of the general character of their compoſition: they were often ill ſelected and frequently ill managed. Even when chance or choice produced a good figure, it was ſpun out through ſo many minute circumſtances, that judgment was diſguſted and atttention fatigued. Hence in thoſe writers may be found pages filled with materials, which, under the management of correct taſte, might have been raiſed to ſublimity or poliſhed to elegance, but which, in their hands, degenerate into quaintneſs and puerility. The rules for regulating the uſe of metaphor they frequently inverted, and inſtead of recurring to the metaphoric expreſſion when the literal one was mean or vulgar, they, in many inſtances, are found uſing trite and vulgar words metaphorically to convey, what in the literal expreſſion would not have been deſtitute of dignity.

Of *unity* in their ſentences they ſeem not to have been at all ſtudious. It would be difficult to find any production of that day

day in every page of which one may not find numerous inſtances of two, and ſometimes three or four, diſtinct and independent thoughts crowded into one ſentence: on the other hand, the inſtances are, perhaps, not more rare, of clauſes naturally and cloſely connected, as parts of the ſame whole, being divided into ſeparate periods.

From this negligence of diviſion, and inattention to minute circumſtances, this ſtyle has acquired an apparent freedom which in more poliſhed and elaborate compoſition is in vain looked for. The mind, regardleſs of accuracy in expreſſion, ſeems to have been attentive only to ideas—The torrent of thought is poured forth without heſitation or reſtraint, and rolls with at leaſt a free, if not a clear current. But, on cloſer examination, what appeared to be freedom of ſtyle is often found to be only looſeneſs of expreſſion. What was gained in the eaſy flowing of the ſentence was loſt by its want of perſpicuity, and when the period which filled the ear with harmonized ſounds comes to be conſidered by the underſtanding it is perceived to be inflated with ſuperfluous verbiage, or darkened by unneceſſary prolixity.

That he who uſes two words to expreſs one idea either does not underſtand, or does not attend to the meaning of the words he uſes, has often been obſerved. Whatever truth there may be in the remark, it is certain the writers of this period are frequently chargeable with this practice. Nor were they deficient in *preciſion* only, which is always deſtroyed by the introduction of

of ſuperfluous words; they, perhaps, not leſs frequently violated *propriety:* they not only uſed words in pairs to expreſs ſingle ideas, but of thoſe words, of which the meaning was not thus propped by ſubſidiary phraſes, the uſe was, in many inſtances, manifeſtly improper, and in ſtill more vague. In the uſe of corponding particles, too, the ſtyle of 88 was faulty in a great degree †. Nor was it erroneous merely in the manner of connecting the component clauſes of ſentences together; it was equally ſo in the connection of the ſentences themſelves Among the writers of this period it is that we find the practice moſt prevalent of making *which*, at the beginning of one ſentence, a relative to the whole of that which precedes; and ſurely nothing in ſtyle can be more inartificial, nothing more repugnant to preciſion or to taſte.

Besides thoſe more important defects, there were others whicl equally violated grace though they did not equally induce obſcurity. Such are the frequent uſe of compound adverbs, *whereupon*, *whereas*, *wherein*, &c. the uſe of the obſolete pronominal adjectives *mine*, *thine*, before ſubſtantives; the formation of the ſuperlative degree by *eſt* in pollyſyllable adjectives; and the frequent introduction of colloquial idioms. Of theſe charges it will not be neceſſary to give any other proof than a reference to the

† Not unfrequently, for inſtance, *neither* and *or*, *either* and *nor* are made to correſpond, and *as* is often uſed as a relative to a ſubſtantive with *ſame* before it, "in "the *ſame* manner *as* is related, &c."

the writings of that day; if examples be wanted, they may be found thickly ſtrewed in every page of them *.

NOTWITH-

* A few of theſe examples are here ſubjoined, taken from Atterbury, Burnet, Tillotſon, Petty, Temple, &c. in which, it is believed, all the faults which have been above attributed to the ſtyle of this period are exemplified. Theſe inſtances have not been ſelected with a view to exhibit the moſt faulty paſſages in the works of the reſpective writers, but are ſuch as occurred on a caſual opening, and in ſome one compoſition of no great length, in each author. This mode of ſelection candour dictated; for where is the author who has written much, in whoſe writings invidious induſtry might not collect a multitude of paſſages cenſurable for their inaccuracy, or ridiculous for their weakneſs?

Tillotſon, in his ſermon on the incarnation, ſays, "God ſhewed not ſuch *grace* "and *favour* to the angels: the Son of God became mortal and miſerable, and "ſubmitted to all things that are accounted moſt *miſerable* and *calamitous* in our na- "ture." "He was the meekeſt endurer of ſufferings *that ever was*." Synonimes—a flat expreſſion, and a drag on the ſentence.

"*Which*, how it can be ſo eaſily conceived upon any other ſuppoſition, I muſt "confeſs I am not able to comprehend." Inartificial connection and bad grammar, *which* being referred to the whole of the preceding ſentence, and ſtanding without a verb.

"The tongues of men and angels, *as* they are ſaid to be a worthleſs gift in com- "pariſon of charity, *ſo* are they not able to ſet out *half* the *worth* and excellence of "it."

"*As* it makes a kind of atonement to God for all the faults we commit, *ſo* doth it "make *an amends* to us for all the trouble we are at."

Theſe two paſſages exemplify a poize between the two parts of a ſentence by *as* and *ſo*, which though perhaps not very faulty in itſelf becomes cenſurable from the frequency of its occurrence in the writings of this æra. They are beſides chargeable with ſynonimes, with baldneſs of expreſſion, with bad grammar and colloquial familiarity.

In Petty's Tract on the Conſtitution and Laws of England, we meet with the following:

"The next article may require a more eſpecial *care* and *conſideration* of the juſtices; "and here I judge we are no way deficient in *law*, but altogether in the *execution*

NOTWITHSTANDING the very general prevalence of thoſe errors in the ſtyle of Engliſh proſe at the period of the revolution, it muſt not

" of it. We ſhould not ſay our *laws* want reformation when 'tis only *ourſelves* " that want it. If our lawgivers never more *amend our laws*, we may *mend our ways* " with thoſe we have already. Care ſhould be taken to *keep* our highways in *repair*, " when the nation has been at the charge to *put* them in *good repair*." Synonimes and puerile antitheſes.

" Hence I ſhall *divide* and *diſtinguiſh* juſtices of the peace into honorary and acting." " But there is no neceſſity for that *neither*, &c." Synonimes and [illegible] negative.

Burnet, in his ſermon at the Rolls Chapel, " That we ought [illegible] *neither* to " our reaſon *nor* our ſenſes." Double negative. " To demand an *equity*." An improper uſe of the word *equity*, as well as a harſh and coarſe expreſſion.

" On the contrary, in dark ages, nothing was more common than pretended *appa-* " *ritions* and *voices* to confirm *the* impoſture; *which* have vaniſhed in an age that is " more apt to ſuſpect and examine ſuch things, as the illuſions of our dreams fly from " us whenever we are awake." This ſentence is perfectly characteriſtic of the ſtyle of 88: *the* before impoſture is improperly uſed, as it is impoſture generally which he ſpeaks of, and to which therefore the definite article cannot be applied: the relative *which* is made to agree, not with the noun immediately preceding, but with *apparitions* and *voices*: to both of theſe nouns the verb *vaniſh* is applied, with the common inaccuracy of the writers of this period, though it can in propriety agree only to the firſt, for no man would talk of a *voice vaniſhing*. What follows in this ſentence ſhould have been matter for a new period, for to have deſcribed the prevalence of ſuperſtition through ſeveral ages was enough for one ſentence, and to deſcribe the ſuperiority of the preſent age another would not have been too much. *Suſpect* and *examine*, though certainly not ſynonimous, for many who ſuſpect will often not take the trouble to examine, yet, in the uſe that is here made of them, appear to be joined only for the ſake of company. In the laſt clauſe *when* would probably be much better both for ſound and ſenſe than *whenever*. " If reaſon be " once given up, no wonder if wealth and other ſecular advantages were *thrown* " *into the bargain*." A figure more fitted for the ſhop or the ſhambles than the writings of a biſhop.

In

not be underſtood that excellence in compoſition was at that time no where to be met with. Dryden ſtands a great and illuſtrious inſtance

In his Tract on the Gunpowder Treaſon, he talks of " the *head* contrivers of it, and of " heading the party that was *thereabouts*."

" They that knew their own work and were aſſigned to ſome particular office, " might know no more what they did, than *every little officer* in a regiment is " acquainted with the debates and reſolves of a council of war." Two inſtances of impropriety, *every* for *any*, and *little* for *petty*. Of *debates* and *reſolves* one is ſuperfluous.

" *Inſomuch* that full and clear evidence *as* we might have had, &c." " It was ne- " ceſſary for them to *ſtand upon their own vindication*, and to *vindicate* themſelves after " the moſt ſolemn way imaginable." Inaccurate connection and tautology.

" Till this order was univerſally *diſſolved* and *extirpated*." Synonimous. " *If ſo be* " it might be done." Vulgariſm. " I ſhall ſhew they might *ſtand upon* their own " innocency and juſtification to *the* death." In his Letter on the Diſcovery of the Plot, he ſays, " the Church *has not* been *acted* with the ſame ſpirit, *nor* followed the " ſame doctrines, &c." *Acted* uſed improperly for *actuated*, and *nor* uſed for *or*. " Theſe doctrines will ſoon be *taken off the file*." A trite and degrading metaphor.

Atterbury on the Miraculous Propagation of the Goſpel, ſays, (and certainly it is not one of his moſt faulty ſentences) " Its original ſucceſs was a *perpetual ſtanding* mi- " racle of ſufficient force to evince its divine extraction, from the *beginning of* " *Chriſtianity to the* end of it." It was unneceſſary to ſay, that what was a *perpetual* miracle was alſo a *ſtanding* one; and that is unqueſtionably careleſs and inaccurate compoſition, in which one finds ſuch a clauſe as this, where he talks of " the " *extraction of Chriſtianity, from the beginning to the end of it. Chriſtianity*, too, is here " uſed for the *Chriſtian æra*.

" The Moſaic law was intended for a ſingle people, who were to be ſhut in, *as it* " *were*, by a *fence* of legal rites and typical ceremonies, and to be kept by *that means* " *ſeparate* and *unmixed* till the Meſſiah ſhould appear, and *break down the fence*, and " *lay open the enclоſure*." This paſſage exemplifies more faults than one; it will ſuffice however to remark, that it contains a metaphor expanded till it becomes vapid and puerile.

 On

inſtance of correctneſs and elegance in proſe, as well as of harmony and fire in poetry. His Prefaces and his Critical Eſſays are written in

On the power of charity he obſerves that this virtue, " if it have the *reins given to it*, will *run away with the rider*." This is burleſque, and he is not much ſhort of it when he tells us, that " God has *twiſted* our duty and our intereſt together," and that the other virtues " *ſtand on their own bottom*."

" Charity is the queen of virtues; the reſt are in her train and retinue, *as it were*, " conſtantly attending her, *appearing* and *diſappearing*." Another inſtance of ſuperfluous words, over-wrought metaphor, and of a heavy adjection clogging the ſentence.

In his ſermon on the Unity, Tillotſon talks of the Sun, as " the moſt *worſhipful* of all ſenſible beings," as if he wiſhed to raiſe a ludicrous idea in the mind rather than to exhibit that luminary " as the eye and ſoul of this great world." Of the heroes he ſays, that " for their great and *worthy* deeds, when *they lived upon earth*, they were " diſtinguiſhed by poſthumous honours." But it would be ſuperfluous to dwell on ſuch paſſages as theſe while one can find ſuch a ſentence as the following, which concenters in itſelf almoſt all the errors with which we have charged the ſtyle of 88.

" One cannot deny the frame of this world which he *ſees with his eyes*, though from " *thence* it will follow that either that or ſomething elſe muſt be of itſelf; *which* yet, as " I ſaid before, is a *thing which* no man can comprehend *how it can be*." In this ſentence it is difficult to collect to what antecedent *thence* is referred; it can properly refer only to the preceding propoſition " one cannot deny the frame, &c." and referring to that the concluſion will not follow; it muſt therefore refer to " *frame*," and the connection in that caſe will be obſcure and illogical. " *Which* yet, as I ſaid before, is a thing, &c." Here we find, after two or three readings, that the relative which is connected with the *laſt clauſe* of the preceding member of the ſentence as an antecedent, and the propoſition, contained in that clauſe, is called a thing; the latter *which* is a relative to this *thing*, that is to the foregoing *which*—that is to the propoſition in the laſt clauſe of the firſt member of the ſentence; and this latter *which* ſtands without any verb, for the clauſe " *how it can be*" ſtands as the objective caſe to " *no man can com-* " *prehend*." Such a ſentence ſeems the *ne ultra* of looſe, confuſed and negligent ſtyle.

From Tillotſon we ſhall give but two other examples—the firſt to illuſtrate the inartificial manner in which he divided his ſentences; the other, from his diſcourſe on the difficulty of reforming vicious habits, to prove how extremely attached he, as well his contemporaries, was to the practice of giving to every word a fellow.

" The

in a manner which, as has been obſerved even by the faſtidious Johnſon, would not, even at the preſent day, after the lapſe of more

" The temporal *calamities* and *ſufferings* with which the Jews had been haraſſed, " had weaned them from the conſideration of temporal promiſes, and awakened their " minds to more ſerious thoughts of another *world. It being natural* to men when they " are deſtitute of preſent comfort, to ſupport themſelves, &c." Evidently theſe two ſentences ſhould have been molded into one—the ſenſe, as well as the expreſſion, required it. " From his great *mercy* and *pity* declared to us in all thoſe gracious *means* and " *methods* which he uſeth for our recovery, and from his *readineſs* and *forwardneſs* after " all our rebellions, &c." " The *cuſtom* and *frequent practice* of any thing begets in us a " *facility* and *eaſineſs* in doing it; it turns the *ſtream* and *current* of our actions ſuch " a way."

Sir William Temple has been conſidered as one of the fineſt writers of this period; the following paſſages, from this Tract on the Low Countries, with which we ſhall conclude theſe extracts, evince that he is not exempt from the common errors of his cotemporaries:

" Charity ſeems to be very national. Among the many and various hoſpitals that " are *in every man's curioſity and talk* that travel this country, I was affected with none " more than that of Euchuyſen for aged ſeamen, which is *contrived, finiſhed and* " *ordered* as if it was *done* with the kind intention of ſome well-natured man, that " thoſe who had paſſed their *whole* lives in the *hardſhips* and *incommodities* of the ſea " ſhould find a retreat ſtored with all the *eaſes* and *conveniences* that old age is capable " of feeling or of enjoying: *for*, one of thoſe old ſeamen entertaining me *a good* " *while* with the plain ſtories of fifty years voyages and adventures *while* I was " viewing the hoſpital and the church adjoining, I gave him a piece of their coin " about the value of a crown piece: He took it ſmiling, and offered it to me again, " *but* when I refuſed it, he aſked me what he ſhould do with money—for *all that* " *ever they* wanted was provided for them at their houſe: I left him to overcome his " modeſty as well as he could, but a ſervant coming after me ſaw him give it to a " little girl *that opened the church door as ſhe paſt by him; which* made me reflect, &c."

" Wine to hot brains being like oil to fire, and making the ſpirits, by too much " lightneſs, evaporate into *ſmoak* and *perfect airy imaginations*, or by too much *head*, " rage into frenzy, or at leaſt into *humours* and *thoughts* that have a great mixture " of it."

more than a century, be thought obſolete, and might, even now, be preſcribed as a model of many of the graces of compoſition. Its eaſy and natural flow, its gracefulneſs and rich variety, cannot, after all the improvements which in ſo long a period have been made in our language, be eaſily exceeded by modern taſte and ſkill in writing. Yet even Dryden himſelf, with all his merits, affords ſome inſtances, though certainly they are but thinly ſcattered, of moſt of the faults of which his contemporaries are guilty. In his Eſſay on Heroic poetry, for inſtance, we find ſuch a paſſage as the following: " For their (the poets) ſpeculations on this ſub-" ject are wholly poetical; they have only fancy for their guide, " and that being *ſharper* in an excellent poet than in a heavy, " phlegmatic gownſman, will *ſee farther* in its own empire, and pro-" duce *more ſatisfactory motions* on thoſe *dark and doubtful* problems." He is ſometimes ungrammatical, and ſometimes violates propriety, as when he ſays " to which I have added ſome original, *which*, " whether *they* are equal or inferior to my other poems *an* author " is the moſt improper judge, and therefore I leave them wholly " to the mercy of the reader." But it would be invidious to enumerate examples of this kind in ſuch an author as Dryden, whoſe beauties, both in proſe and poetry, ſo far out-number his defects, and whoſe ſuperiority over his cotemporaries is too evident to the moſt ordinary reader to be denied or doubted.

If the character of this period for ſtyle could be ſaved by the merits of one or two individuals, Spratt might be adduced with Dryden to vindicate the taſte of his age. In his works may be found paſſages nicely correct and of extreme elegance. In general

he

he avoids ſynonimes, makes a happy ſelection of words, and forms them into ſentences of much harmony. Though it cannot perhaps be truly ſaid that in the management of his metaphors he is always happy, yet it would be difficult to find in him ſo many inſtances of over-wrought, or ill-choſen figures, as in any of his contemporaries equally voluminous. In the connection of his ſentences he probably is not ſo blameleſs. His hiſtory of the Royal Society has been praiſed for its compoſition, and that it is ſtill read is a proof that it deſerves the praiſes which have been given to it; but I am not ſure that in his leſs celebrated "Account of the Plot," there do not occur paſſages which better merit the character of fine writing than any which are to be met in his hiſtory of the Society, or any other of his tracts.

Had not Hooker written too early† to rank among thoſe writers of whom we have been ſpeaking, he would have afforded ample ſubject of commendation for purity of language and preciſion in ſtyle; in other inſtances, perhaps, ſome for cenſure. At preſent it is enough to obſerve that by comparing the writings of Hooker with thoſe of the beſt authors of 88, it will appear that in the intervening century much leſs improvement had been effected in the ſtyle of Engliſh proſe than has taken place in the interval between the Revolution and the preſent day.

With all theſe faults in ſtyle, the writers of this period are to be reckoned among thoſe who have raiſed moſt high the literary character

† Hooker died in the year 1600.

character of their country. They have, indeed, a claim to higher praiſe than that of poliſhed compoſition; they abounded in good ſenſe, and in fine genius, and had an extenſive knowledge of the lettered and of the living world. Let not, therefore, the flimſy and ſuperficial, though, perhaps, more accurate writer of modern times, pretend that becauſe his trifles ſparkle with more brilliancy and exhibit a ſmoother ſurface, they are, therefore, ſuperior to the rich and ſolid, though leſs poliſhed, productions of this period: our anceſtors wrote for fame as they ſtrove for liberty, with the ſtrong minds of men more attentive to things than words; we, perhaps, in the ſickly taſte of modern refinement, prefer form to ſubſtance, and ſubſtitute elegance of expreſſion for ſound ſenſe.

With Addiſon and his contemporaries originated the firſt variation that occurred, ſubſequent to the Revolution, in the compoſition of Engliſh proſe. Though the diffuſe ſtyle ſtill continued to prevail, it was no longer the looſe, inaccurate and clumſy ſtyle by which the compoſitions of his predeceſſors were diſgraced. So great, indeed, was the improvement, and ſo ſtriking the variation introduced by Addiſon, that he who compares the productions of this elegant writer with thoſe of the beſt writers of 88, will find it difficult to avoid ſurpriſe, how, with ſuch precedents before him, he could have riſen at once to a degree of excellence in ſtyle which conſtitutes him a model for imitation. The forced metaphor, the dragging clauſe, the harſh cadence, and the abrupt cloſe, are all of them ſtrangers to the works of Addiſon. In the ſtructure of his ſentences, though we may ſometimes meet marks of

of negligence, yet we can ſeldom find the unity of a ſentence violated by ideas crowded together, or the ſenſe obſcured by an improper connection of clauſes. Though, like his predeceſſors, he frequently uſes two words to expreſs one idea, yet, in this inſtance, he is leſs faulty than they; and, among the variations introduced by him, we muſt reckon a more ſtrict attention to the choice of words, and more preciſion in the uſe of them.

Of figurative language Addiſon has always been acknowledged the moſt happy model. He was, indeed, the firſt of the Engliſh proſe writers who were equally excellent in the choice and in the management of their figures. Of thoſe who preceded him, it has been obſerved that they were frequently unhappy in both inſtances; that their metaphors either were ſuch as tended rather to degrade their ſubject than to give it dignity and elevation; or that when they were well choſen, they were ſpoiled by the manner in which they were conducted, being detained under the pen until their ſpirit evaporated, or traced until the likeneſs vaniſhed. Addiſon avoided both faults: his metaphors are ſelected with care and taſte, or rather ſeem to ſpring ſpontaneouſly from his ſubject; they are exhibited to the mind but for a moment that the leading traits of ſimilitude may be obſerved while minute likeneſſes are diſregarded—like thoſe flaſhes of electric fire which often illumine a Summer's night, they ſhed a vivid, though a tranſient luſtre, over the ſcene, and pleaſe rather by the brightneſs with which they gild the proſpect than the accuracy with which they ſhew its beauties.

Should it be doubted, whether the improvement of ſtyle which took place in the time of Addiſon—that variation which ſubſtituted uniform and correct neatneſs in compoſition, for what was looſe, inaccurate and capricious, be juſtly attributed to him—the doubt will vaniſh when it is remembered that in no work prior to his time is an equal degree of accuracy or neatneſs to be found, and even among thoſe periodical papers to which the moſt eminent of his cotemporary writers contributed, the Clio of Addiſon ſtands eminently conſpicuous. It was, indeed, from the productions of that claſſic and copious mind that the public ſeems to have caught the taſte for fine writing which has operated from that time to the preſent, and which has given to our language perhaps the greateſt degree of elegance and accuracy of which it is ſuſceptible—for if any thing is yet to be added to the improvement of the Engliſh ſtyle, it muſt be more nerve and muſcle, not a nicer modification of form or feature.

——— ſectantem levia, nervi
Deficiunt animique:

While Addiſon was communicating to Engliſh proſe a degree of correctneſs with which it had been, till his time, unacquainted, Swift was exemplifying its preciſion and giving a ſtandard for its purity. Swift was the firſt writer who attempted to expreſs his meaning without ſubſidiary words and corroborating phraſes. He nearly laid aſide the uſe of ſynonimes in which even Addiſon had a little indulged, and without being very ſolicitous about the ſtructure or harmony

mony of his periods, ſeemed to devote all his attention to illuſtrate the force of individual words. Swift hewed the ſtones, and fitted the materials for thoſe who built after him; Addiſon left the neateſt and moſt finiſhed models of ornamental architecture.

Of the character which is here given of theſe two writers it is unneceſſary to give proof by quoting paſſages from their works, for two reaſons; the one is, that their works are in the hands of every body; the other, that the qualities which we attribute to their ſtyle are ſo obvious that it were ſuperfluous to illuſtrate them.

Besides thoſe firſt reformers of the ſtyle of 1688, there were others, contemporary with them, who contributed to promote the work which they did not begin. Bolingbroke and Shaftſbury, like Addiſon, were elegant and correct, and ſeem from him to have derived their correctneſs and elegance. Of this, ſo far as it concerns Shaftſbury, there is a moſt remarkable proof*. His Tract, entitled "An Enquiry concerning Virtue," was in the hands of the public in 1699, in a ſtate very different indeed from that in which his lordſhip publiſhed, in the year 1726. It partook of all the faults which were prevalent in the ſtyle of that day, but particularly in the length of its periods, and the inartificial connection of them. In the edition of 1726 thoſe errors were in a great meaſure corrected; the ſentences are broken down, and molded with much

 elegance

* See Blair's Lectures.

elegance into others leſs prolix; and ſharing in ſome degree all the beauties of Addiſon's ſtyle, except thoſe which perhaps his lordſhip could not copy, its eaſe and ſimplicity. Indeed Shaftſbury, in the form in which we now have him, appears to be more attentive than Addiſon to the harmony of his cadence, and the regular conſtruction of his ſentences; and certainly if he has leſs ſimplicity has more ſtrength. Bolingbroke, too, participating in correctneſs with Addiſon, has ſome topics of peculiar praiſe; he has more force than Addiſon—and—what may appear ſtrange, when we conſider how much more vehement and copious he is, has more preciſion. The nature of the ſubjects on which Bolingbroke and Shaftſbury wrote naturally tended to make them more attentive to preciſion than Addiſon. Theſe ſubjects were principally abſtract morality and metaphyſics—ſubjects of which no knowledge can be attained but by cloſe and ſteady thinking, or communicated but by words of definite and conſtant meaning. The language of Addiſon, however elegant in itſelf, or however admirably adapted by its eaſy flow to thoſe familiar topics which are generally the ſubjects of diurnal eſſays, was too weak for the weight of abſtract moral diſquiſition, and too vague for the niceties of metaphyſical diſtinction. It was fitted for him whoſe object was to catch what floated on the ſurface of life; but it could not ſerve him who was to enter into the depths of the human mind, to watch the progreſs of intellectual operation, and embody to the vulgar eye thoſe ever fleeting forms under which the paſſions vary.

It might afford much matter of curious ſpeculation to the philologiſt, to enquire whether it was this aptitude in the language of Addiſon to thoſe light topics of writing in which he excelled that directed his choice of ſubjects, or whether his peculiar caſt of ſtyle was formed by his choice of ſuch topics. Probably both operated, or rather both were effects of the ſame cauſe. A man's caſt of thought gives a character to his ſtyle, and where choice is free, the ſubject for compoſition is determined by the complexion of the mind. But whatever might have been the cauſe of Addiſon's excellence in point of ſtyle, or that of his compeers Bolingbroke and Shaftſbury, it is certain that for ſome time previous to the revolution there had been cauſes in operation which neceſſarily tended to produce a general improvement in the ſtyle of Engliſh proſe. Some of thoſe have been already hinted above; there are others that deſerve mention. Not only had the religious and political diſputes which had called forth and in ſome meaſure ſharpened the intellect of the nation, introduced a poſitive improvement in compoſition—they did more; they ſowed the ſeeds of ſtill farther and more important improvements, by diffuſing a taſte, and in ſome meaſure creating a neceſſity for ſtudy. Claſſical learning had been revived by the reformation. Inſtead of the barbariſms of monkiſh Latin, the public had gotten a taſte, not only of the fine writings of antient Rome, but of the compoſitions of the poets and hiſtorians of Greece, who had been ſo long buried beneath the rubbiſh of popiſh ignorance. Literary conteſts, created by political differences, diffuſed ſtill more widely a knowledge of thoſe beſt models of compoſition—for on a queſtion of

government

government or of liberty, to whom could reference be ſo ſafely or naturally made as to thoſe who were ſuppoſed to have known beſt the theory of the one and the practice of the other? In fact, claſſical learning was perhaps never more cultivated in England than for ſome time previous to the revolution, and in ſuch circumſtances it was impoſſible that ſtyle ſhould not have improved in its moſt eſſential qualities.

It has been already obſerved that the ſtyle of Dryden was in almoſt every point of view much ſuperior to that of the writers of his day. So far then as he exhibited to the public better models of proſe compoſition, ſo far muſt he have contributed to improve the ſtyle of that and the ſucceeding period. But excluſive of this excellence in his writings, the nature of the ſubjects of which he treated in many of his proſe works contributed ſtill more to improve the taſte of his countrymen in compoſition. Many of his prefaces are profeſſedly critical diſſertations on various kinds of writing, and in theſe he communicated to the public, even to thoſe of them who were not the learned, ſuch true principles of taſte, and ſound rules of judgment, as muſt neceſſarily have accelerated their approach to that accuracy and elegance which Engliſh proſe ſo ſhortly afterward began to diſplay.

There was a ſtill more immediate cauſe of improvement in the ſtyle both of his Proſe and Poetry. The poliſh and refinement of the court of Charles II. of which the diſſoluteneſs was the grave of the morality of the nation, was perhaps the parent of much of that elegance which characterized Addiſon, and thoſe authors who cultivated

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our language in the ſucceeding reigns. The public taſte was improved by ingrafting the light beauties of French literature on the ſolid ſtock of Engliſh learning; and then by a happy concurrence of circumſtances our language came to unite copiouſneſs and ſtrength with grace and elegance.

So wide was the variation of the ſtyle of Addiſon and his cotemporaries from that of the period of 1788, that no ſubſequent variation was ſo great or ſo obvious. His ſound judgment and fine taſte raiſed the language in which he wrote, at one effort, as much above its former level as the continued improvements of ſucceeding writers raiſed it above that at which he left it. Improvement, however, it did receive, and among thoſe who contributed to that improvement the amiable Goldſmith holds, perhaps, the higheſt place. Poſſeſſing all the qualities which conſtitute a fine writer, intellect, erudition, and above all, *taſte* in compoſition, diſtinguiſhed equally by the mild fertility of his imagination, and the correct copiouſneſs of his language, he ſeems to have carried the improvements of Addiſon's ſtyle almoſt as far as they could be carried. But even in this its higheſt ſtate of excellence it was ſtill the ſtyle of Addiſon, diſtinguiſhed by nothing but a greater degree of thoſe qualities for which the writings of Addiſon were remarkable. As it would, therefore, be improper, perhaps, to call thoſe improvements *variations* in ſtyle, it will be permitted in an eſſay of this nature to paſs them over without more particular notice, and come at once to thoſe changes which have been introduced by Dr. Johnſon—the coloſſus of Engliſh literature—the multiplicity and excellence of whoſe

whoſe writings have raiſed up ſuch an hoſt of imitators, of friends and of enemies.

JOHNSON varied the ſtyle of Engliſh proſe in three inſtances—in the form of its phraſes, in the conſtruction of ſentences, and in diction. To deſcribe accurately theſe variations were to give an Eſſay on his ſtyle and writings; and this has been already ſo ably done by a member of this Society * that it would be unſafe and unneceſſary again to attempt it. The nature of this Eſſay, however, requires that on this ſubject ſomething ſhould be ſaid, not to point out his beauties or defects, but merely to mark the variations which he has introduced.

OF the changes in phraſeology introduced by Johnſon the principal is the ſubſtitution of the ſubſtantive expreſſing the quality in the abſtract for the adjective expreſſing it in concrete, or, the verbal ſubſtantive for the verb itſelf. Thus when he ſays that "none of the axioms which recommend the antient ſages to "veneration ſeems to have required leſs extent of knowledge "or leſs perſpicacity of penetration than the remark of Bias, "οι πλεονες κακοι," he ſubſtitutes extent for extenſive, and *perſpicacity* for *acute*: and when he makes Dicaulus ſay that "every "tongue was diligent in *prevention* or *revenge*," he makes him ſay what in the language of other men would have been "diligent "to prevent or to revenge."

BY

* Vide Dr. Burrowes' Eſſay on this ſubject in the Memoirs of the Royal Iriſh Academy.

By the frequent uſe of this phraſeology Johnſon has given a degree of ſtrength and ſolidity to his ſentences which he could have given them, perhaps, by no other means, The advantages of it have been pointed out in the eſſay above alluded to; the caſes in which it may properly be uſed, and the inſtances in which Johnſon has uſed it improperly, are there mentioned, and to mention them again would be but to repeat what has already been eloquently ſaid.

In the conſtruction of his ſentences he has many peculiarities. One of theſe is, the habit of placing the oblique caſe at the beginning, and introducing between it and the word by which it is governed ſome qualifying circumſtance. Inſtances abound: "*Of two objects tempting at a diſtance on contrary ſides*, it is im- "poſſible to approach *one* but by receding from the *other*."— "*Many concluſions* did I *form*, and many experiments did I *try*, &c." "*From the hope* of enjoying affluence by methods more com- "pendious than thoſe of labour, and more generally practicable "than thoſe of genius, *proceeds* the common inclination to experi- "ment and hazard," &c. &c.

Of this practice the principal effect ſeems to be that of ſtrongly impreſſing the mind by exhibiting firſt to its view the principal object of the ſentence. In grave compoſitions it gives a tone of dignity and ſtrength which admirably correſponds with the nature of the ſubject, and with reſpect to ſound its advantages are equally important, as by affording a liberty of tranſpoſition

it enables the writer to arrange his clauſes in the moſt harmonious manner. The diſadvantages of this practice are, that it gives a formality to compoſition which is not adapted to the eaſy familiarity of the lighter kinds of writing, and, by leading too frequently to tranſpoſition, may ſometimes induce obſcurity.

It may be reckoned among his peculiarities of this kind, that he crowds together, generally at the end of his ſentences, a number of phraſes ſimilarly conſtructed. Perhaps there is no mode of expreſſion of which he gives ſo many examples. "He "who is unfurniſhed with any arts that might amuſe his leiſure "is condemned to wear out a taſteleſs life in calamities *which* "*few will hear*, and *which none will pity*." "A careleſs glance on "a favourite author is generally ſufficient to ſupply the firſt hint or "ſeminal idea, which enlarged by the gradual accretion of matter "ſtored in the mind, is, by the warmth of fancy, eaſily *expanded* "*into flowers*, and ſometimes *ripened into fruit*." "—— to whom "we ſunk into humble companions without choice or influence, "expected only *to echo their opinions*, *facilitate their deſires* and *ac*- "*company their rambles*." "When the trader pretends anxiety "about the payment of his bills, and the beauty remarks how "frightfully ſhe looks, then is the lucky moment to talk *of* "*riches*, or *of charms*, *of the death of lovers*, or *the honour of a* "*merchant*."

There is, probably, no mode of conſtructing a ſentence better calculated than this for introducing, without confuſion or obſcurity, a great

great number adjunct ideas. To a mind ſtored like that of Johnſon with much of the beſt learning of antient and modern times, and with that knowledge which only an attentive obſervation of life can beſtow; to a ſagacity like his, which ſaw almoſt intuitively through a chain of conſequences, and to a comprehenſive mind, ſuch as he poſſeſſed, which took in at a glance a great number of collateral circumſtances, this ſtructure of a ſentence was a neceſſary inſtrument of communication; it gave ſimplicity to what was complex, and unity to what was manifold. But let the writer who has not Johnſon's ſtock of ideas, his ſagacity or his comprehenſion, beware of imitating. When trivial circumſtances are enumerated in this pompous phraſe, or words not of diſtinct meaning exhibited in long-ſounding triods, good ſenſe and good taſte are diſguſted: the dwarf in giants armour is more contemptible than in his native littleneſs.

But however the ſtyle of Johnſon may be characterized, or however Engliſh proſe compoſition may have been improved by theſe peculiarities of conſtruction, it is by his nice ſelection and correct uſe of words that *he* is principally diſtinguiſhed, and the Engliſh language principally benefitted. The ſtudent who, in tranſlating Virgil into other Latin, complained of the difficulty of his taſk, "*quia optimum quodque verbum Virgilius uſurpavit*," becauſe Virgil had preoccupied the words beſt fitted to expreſs his meaning, paid to the Latin poet a compliment which might with equal truth be paid to the Engliſh moraliſt. It would be difficult to convey in ſo many other wordsthe preciſe import of any ſen-

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tence which he has written. There are few if any words ſynonymous in any language: Johnſon, who could diſtinguiſh the moſt minute ſhades of difference in the meaning of terms, always choſe that which belonged excluſively to the idea he would expreſs; and where the language afforded no word that would expreſs his thought with preciſion he reſorted to a Latin word, and giving it an Engliſh dreſs and the ſtamp of his own authority, adopted it into the language.

For the frequency of theſe adoptions Johnſon has been blamed; and when an Engliſh word could be found commenſurate in its meaning to the idea he would convey, and not debaſed by vulgar uſe, he was, no doubt, blameable in reſorting to another language. That he has ſometimes juſtly incurred this cenſure it were vain to deny: but it will be found, perhaps, on examination, that he did not *often* reſort to exotic words, when he could have found Engliſh words of equal force and equal dignity. He did not generally, with the jealous policy of a conqueror, raiſe foreigners to favour to the excluſion of native worth; but in the true ſpirit of a patriot, ſought abroad for a ſupply of thoſe wants which he found to prevail at home.

The Engliſh is, perhaps, the only language ſprung from the Gothic ſtock into which Greek and Latin words can eaſily be adopted, and it is to this facility of adoption that it owes its ſuperior ſtrength and richneſs. Johnſon, therefore, when he adopts from thoſe languages words more appropriate to his meaning than the Engliſh language could furniſh, does only that which

which had been done by others before him, only carries farther an improvement which he did not begin, and adds to thoſe ſtores which the induſtry of others had begun to accumulate. This conſideration however will not always bear him out blameleſs; ſome words he has adopted, for the adoption of which he cannot plead either neceſſity or uſe, for he could have found at home words of preciſely the ſame import and of not leſs dignity. But it is contended that he has not *often* thus erred; that on the whole he has enriched the Engliſh language, and that, therefore, he deſerves not merely impunity but praiſe.

Besides theſe diſtinguiſhing features in the ſtyle of Johnſon, by which he has varied the ſtyle of Engliſh proſe, there is another equally prominent which it ſhall ſuffice barely to mention—the frequent perſonification of virtues and vices, of habits and of actions *.

Subsequent to Johnſon there does not ſeem to have occurred any variation in the ſtyle of Engliſh proſe, notwithſtanding the immenſe numbers of modern writers under whoſe labours the preſs has groaned. Of theſe the greater number have no peculiar character in compoſition; others have imitated, ſome with more and ſome with leſs ſucceſs, the ſtyle of Johnſon; and ſome, as a Burke and a † Reynolds, have riſen in ſome inſtances, perhaps, above him.

Were

* Thoſe peculiarities of Johnſon's ſtyle are found to prevail moſt in his Rambler. His Idler is leſs ſtrongly marked by them, and they are ſtill leſs ſtrong in his Lives; a work by which, perhaps, his excellence as an Engliſh proſe writer is moſt fully confirmed.

† Sir Joſhua Reynolds in his Diſcourſes to the Royal Academy.

Were we now conſidering the abſtract merits of the authors we mention, it would be unpardonable indeed not to beſtow on the vivid energy of Burke, and the mild and chaſte elegance of Sir Joſhua, a large ſhare of attention and panegyric. But ſuch is not the object of this eſſay: we muſt therefore paſs over theſe, as we have paſſed over Goldſmith and others, in ſilence, becauſe though the excellence of theſe writings is ſingularly great, that excellence does not conſiſt in any *variations* which thoſe have introduced into ſtyle, but in the height to which they have carried thoſe principles of compoſition which had been cultivated, though leſs ſucceſsfully, by others before them.

In treating of the various ſtyles which have ſucceſſively appeared from the revolution to the preſent time I have purpoſely omitted ſome which may be thought from their ſingularity to have deſerved notice. Such, for inſtance, is that of Mr. Sterne. This I have paſſed over without remark, becauſe, in the firſt inſtance, it was merely the ſtyle of an individual, and has never been generally adopted by Engliſh proſe writers; and, in the ſecond place, becauſe it ſeems to have been the emanation of an eccentric mind, conveying its thoughts in language as capricious, and, perhaps, affected, as the ſentiments which ſuggeſted them, and as looſe as the moral principles by which they were regulated.

On the POETICAL CHARACTER *of* DOCTOR GOLDSMITH. *By the Rev.* ARCHDEACON BURROWES, *late Fellow of Trinity College, Dublin, and M. R. I. A.*

Read April 22d 1797.

DOCTOR Johnſon's lives of the Engliſh Poets, however his deciſions may in ſome inſtances be controverted, contain a body of the moſt ſound and valuable criticiſm. Regular treatiſes of elementary principles on the ſubject at large are more difficult and leſs entertaining than a collection of judicious obſervations on particular works or particular authors. The latter lie within a narrower compaſs, and require little antecedent preparation in the reader, while the former appear in an abſtract form, and being uſually concluſions by induction pre-ſuppoſe a knowledge of the particulars from which they are inferred, or being deductions from metaphyſical principles in human nature are abſtruſe and technical. General truths are perhaps beſt taught by their ſpecific application, where growing naturally from the inſtance they partake of its familiarity and are developed by its explication.

THE plan laid down by the publiſhers of the collection of Engliſh Poetry to which Johnſon's lives are prefixed has left ſome authors of acknowledged merit unnoticed by the critic. But the life of Savage, which exhibits inceſſant efforts in the biographer to palliate groſs violations of morals and decorum, and the remarks on Gray, in which their author ſeems to be wholly inſenſible to poetical merit of the higheſt claſs, leave us little reaſon to regret that Johnſon was not employed to write the lives or criticiſe the works of all his poetical contemporaries. Among the authors thus left to the animadverſion of humbler critics our countryman GOLDSMITH ſtands conſpicuous. His poetical works altogether do not amount to eighteen hundred lines, and yet ſuch is the tranſcendent merit of his two principal poems, that as a poet Goldſmith is more generally known and celebrated than many of thoſe who have compoſed whole volumes. Criticiſm cannot be more agreeably or more uſefully employed than in tracing out the ſources of his excellence and analyzing its modes, in exhibiting the negligences for which they often compenſate and the culpable exceſs to which they ſometimes run, and in contemplating by detail the literary character of an author of whom it is pronounced from high authority * that "*he poſſeſſed the art of being minute* "*without tediouſneſs, and general without confuſion, and that his* "*language*

* Johnſon in his Life of Parnell.

" *language was copious without exuberance, exact without conſtraint,*
" *and eaſy without weakneſs.*"

GOLDSMITH ſeems to have poſſeſſed every quality which might give popularity to a poet. His language is ſimple, his verſification flowing and familiar, his ſentiments natural and pathetic. His illuſtrations are not pompous exhibitions of learning, alluſions to arts which are little underſtood, and hiſtories which have been little read; his pictures of nature are not elaborate and minute delineations of individual ſcenery; his views of life are not metaphyſical inveſtigations crippled into rhyme, not conjectural fancies of the manners of remote times or imaginary conditions, not diſguſting expoſures of human infirmity or outrageous caricatures of extravagant ſingularities. Always eaſy and unaffected, Goldſmith paints nature as it ſtruck him and manners as he actually obſerved them. His faults too (for ſome faults his greateſt admirers muſt admit in him—faults allied to his excellencies) are certainly not of an unpopular claſs. If his language is frequently colloquial, and occaſionally even ungrammatical, it is never obſcure: if he laments a depopulation in a country where it did not exiſt, he knew that a people who loved to hear of grievances were to be his readers.

JOHNSON pronounced of the Traveller that it was a production to which ſince the death of Pope it would not be eaſy

 to

to find any thing equal. The laſt poetical work of Pope was publiſhed in 1744, and the Traveller appeared in 1765. Within that period Akenſide, Lyttleton, Dyer, Collins, Shenſtone, Maſon and Churchill flouriſhed, and within that period the Odes of Gray and the Seaſons of Thomſon were publiſhed. Whether Johnſon's encomium be not hyperbolical this catalogue may perhaps ſhew, but certainly it ſufficiently expoſes the unreaſonable querulouſneſs which Goldſmith ſhews when ſpeaking of the literature of his age, of the doubts which he expreſſes in the preface to the Traveller as to the reception his poem might meet with, and of the picture which at the concluſion of the Deſerted Village he has drawn of the neglect and conſequent departure of poetry from his country. This is the tranſmitted peeviſhneſs of poets; a conceited language which Goldſmith took up from Pope, and which found ſupport in the *frigid indifference* with which his friend diſmiſſed his dictionary. Johnſon's good ſenſe ſaw the weakneſs in another, and in his life of Pope reprobates and expoſes it, and Goldſmith lived long enough probably to regret it. At leaſt in his later editions of the Traveller he has expunged that paſſage in the preface which affected to ſay that " the ſtrongeſt " and happieſt efforts of poetry could in his age expect to " pleaſe but in a narrow circle." Goldſmith's might not have been the age of the higheſt claſs of writers, but it certainly exceeded all which went before it in the number of judicious and well inſtructed readers.

Of the poets who were his contempories Goldſmith does not ſpeak in favourable terms. The ſhort and common place criticiſms which were purchaſed from him at the extravagant price of two hundred pounds for two volumes of his Beauties of Engliſh Poetry repreſent Thomſon as verboſe and affected, and Shenſtone's ballads as poſſeſſing neither harmony nor ſimplicity. His Hermit is introduced in the Vicar of Wakefield as a contraſt to the Engliſh poetry of the preſent day, which, he ſays, " is nothing but a combination of luxuriant images " without plot or connection—a ſtring of epithets that im- " prove the ſound without carrying on the ſenſe:" and the preface to the Traveller complains of " criticiſms of late in " favour of blank verſe and Pindaric odes, choruſſes, anapeſts " and iambics, alliterative care and happy negligence," and talks of the poet of the day as " a half-witted thing who wants " to be thought a bold man having loſt the character of a " wiſe one—of his tawdry lampoons being called ſatires, his " turbulence ſaid to be force and his frenzy fire." Theſe attacks on Shenſtone, Maſon and Churchill were not all called for by the occaſion: Goldſmith's ſubjects and his manner precluded any compariſon with the two latter, and if any part of his writings might bear reſemblance to any of thoſe of Shenſtone or Maſon he ſhould have conſidered that there was room on the higher grounds of Parnaſſus for more than one poet of the ſame claſs. But the man who could be diſpleaſed at hearing the praiſes of his friend muſt have deemed

deemed all who poſſeſſed excellence in whatever department as his rivals.

To the ſchemes of his two moſt diſtinguiſhed poems objections have been often made. The ſcheme of the Traveller was, as he tells us, an endeavour to ſhew " that there may be " equal happineſs in ſtates that are differently governed from " our own ; that every ſtate has a particular principle of hap- " pineſs, and that that this principle in each" (in his firſt edition he adds, and particularly in our own) " may be carried to " a miſchievous exceſs." This poſition of a particular principle of happineſs to each ſtate, which he aſſumes as a known truth, muſt appear at leaſt a diſputable poſition : that all ſpecies of happineſs are equal cannot be granted, and it is certainly a groſs degradation of human nature to ſay, that after nobler aims are repreſſed

> Low delights ſucceeding faſt behind
> In *happier* meanneſs occupy the mind.

The concluſion which was written by Doctor Johnſon gives us all which Goldſmith's poem rationally eſtabliſhes, that human bliſs centers only in the mind—that ſtate offences and their puniſhments

> To men remote from power but little known
> Leave reaſon, faith and conſcience all their own ;

and

and that therefore under every government happineſs may be attained, inaſmuch as

> Still to ourſelves in every place conſign'd,
> Our own felicity we make or find.

All this is truth and good ſenſe from the author of the Rambler, but ſurely it is very different from Goldſmith's original poſition.

The ſcheme of the Deſerted Village was "to regret the depopulation of England, and to inveigh againſt the increaſe of "thoſe luxuries by which it was occaſioned." Goldſmith had found the leading principles of his Traveller controverted, and in his dedication to the Deſerted Village ſeems aware that the ſcheme of this poem alſo was queſtionable. He is aware that it will be objected that "the depopulation it de-"plores is no where to be ſeen, the diſorders it laments only "to be found in the poets own imagination." To this he ſays he can ſcarce make any other anſwer than "that he ſin-"cerely believes what he had written, and had taken all poſ-"ſible pains in his country excurſions for four or five years "paſt to be certain of what he alleged." There is ſome vanity in ſetting up the ſupport collected in a few country excurſions for a favourite theory publiſhed by him ſome years before, againſt the authority of thoſe whom he acknowledges to be the wiſeſt and beſt of his friends. No doubt the luxury

luxury muſt be injurious by which a country is depopulated, but a foreigner who took his ideas of England in the year 1769 from Goldſmith's Deſerted Village would be ſtrangely miſled. Yet on this imaginary and inſecure foundation has been conſtructed a poem which may be expected to laſt as long as the Engliſh language ſhall endure, and nature and ſimplicity delight.

But though Goldſmith's Theories are not eſtabliſhed truths, the author certainly wrote himſelf into a full perſuaſion of them, and it is our ſatisfaction that they afford topics admirably adapted for diſplaying his peculiar felicities and communicating his ſelected information. About two hundred lines of the Traveller were ſent by him from Switzerland to his brother. It is natural to ſuppoſe that theſe contained the author's deſcriptions of the countries through which he had travelled, and obſervations on the manners of their inhabitants. The ſuperior excellency of the portrait of the Swiſs ſeems to warrant this ſuppoſition. Pleaſed with his own rambling life he ſaw the people apparently happy wherever he went. At his return he ſaw the happineſs of his own country and compoſed his poem on the theory of equal happineſs every where, and in the contraſted characters of the ſeveral ſtates which he had viſited he thought he ſaw the particular principle on which it was founded. As a writer more than as a politician he perceived the powerful influence of party in England,

England, for party he tells us is there the moſt dangerous enemy to poetry. He attempts to moderate the rage of all parties by an endeavour to ſhew that patriotic boaſting is the ſhame of reaſon, ſince nature and art afford equal happineſs every where. The poet, miſled by the different ſenſes of the ſame word, never conſidered that poetical party might ſubſiſt though national ſhould be deſtroyed, or that party might in any ſingle country produce the worſt effects though that country and its neighbours were admitted to be equally happy. But the reader may be fully ſatisfied with any means of introduction to thoſe admirable national characters which actual inſpection had made known to Goldſmith, and which his poetic fancy could ſo beautifully delineate.

In his review of the Engliſh character, under the influence of vanity not yet ſufficiently gratified with public notoriety, and of liberality not limited by prudential experience, he deems every man unhappy who is poor, and every man a ſlave who is not born a legiſlator. What he had ſtated in his Traveller in his next poem he would not contradict. He condemns the luxury which was beyond his reach, and with the eye of a poet he ſees its effects in an imaginary depopulation. His enthuſiaſm became confirmed in its belief—he had talents to deſcribe it pathetically, and by a proceſs ſimilar to thoſe algebraic calculations which from falſe ſuppoſitions elicit the truth, he has made it the occaſion of introducing in his Deſerted

Village images which we feel to be impreſſive, and ſentiments which we acknowledge to be juſt.

The conduct of theſe poems, if not ſtrictly regular, is natural and unembarraſſed: the digreſſions are always ſeaſonable, and the returns eaſy. The Deſerted Village begins with a general view of Auburn in its former ſtate of happineſs and population, which is immediately contraſted with its preſent decay —then the author recurs to more diſtinct particulars of its recollected proſperity—to the clergyman, the ſchoolmaſter and the village ale-houſe—he contemplates the decay—he inveſtigates its cauſes—he contraſts the benefit with the evils of luxury —he paints the horrors and marks by a pathetic detail the progreſs of emigration. If any part appears not firmly rivetted to his ſubject, it is the concluſion, that beautiful eulogium on poetry which no reader would ſhew himſelf ſo coldly attached to method as to give up. The Traveller ſeems to have no part ſuperfluous and none ill placed. To the concluding topic, of which Doctor Johnſon ſays the Deſerted Village is too much the echo, we are naturally led. The omiſſion of the undiſtinguiſhed character of the Netherlands was peculiarly judicious. The only improvement which might be ſuggeſted would be the interpoſing a character of Spain between Holland and England. The connection between theſe as it ſtands in the poem is faſtened on a flimſy feeble minuteneſs thrown unneceſſarily and unreaſonably

unreaſonably into the character of the Dutch. As their diſregard of freedom was certainly not greater than that of France or Italy England is not with better effect contraſted with Holland than it might have been with either of the others. From Holland hiſtory might have led by a natural connection to Spain, and the Spaniſh character would afford an admirable contraſt to the Dutch and the Engliſh, the two between which it would be placed. 'Tis true the poet looks from the Alps, and Spain might lie hid behind the Pyrenees—but I apprehend the miraculous improvement of viſion which from the Alpine heights could diſcern objects ſo minute as the temples of Italy ought not to be reſtrained within common limits, and the ſame poetical perſpective which could have brought the moraſſes of Holland into view could alſo have raiſed the remote parts of Spain above the obſtruction of mountains on its nearer confines. The conduct of Goldſmith's Hermit * is exquiſitely beau-

tiful.

* One paſſage in his Hermit I cannot paſs over without a particular obſervation. It is where the Hermit enumerates the various poſſible cauſes of the ſtranger's apparent uneaſineſs, and, among the reſt, conjectures at *friendſhip unreturned* or *love unregarded.*

> And what is friendſhip but a name,
> A charm that lulls to ſleep;
> A ſhade that follows wealth or fame,
> But leaves the wretch to weep?
>
> And love is ſtill an emptier ſound,
> The modern fair one's jeſt;
> On earth unſeen, or only found
> To warm the turtle's neſt.

The making the Hermit ſuggeſt that particular mode of treatment in love which he had himſelf experienced, and which the ſtory immediately after recognizes, is peculiarly natural, judicious and affecting.

tiful. The intereſting abruptneſs of its opening—the humane and delicate ſentiments in the Hermit's ſpeech, giving ſo affecting and engaging impreſſion of his character—the ſimplicity of the following narrative—his importunate ſolicitation forcing out at laſt the ſtory of the ſtranger ſo judiciouſly delayed, and the ſurprize and pathos of the concluſion, make this little poem one of the moſt finiſhed pieces of affecting ſimplicity in our language.

NATURAL and affecting ſimplicity forms indeed Goldſmith's peculiar excellence. Yet where his ſubject calls for it Goldſmith is not deficient in ſublimity. His deſcription of the rampires artificial pride may ſerve to prove this,

Onward methinks and diligently ſlow
The firm connected bulwark ſeems to grow:
Spreads its long arms amidſt the wat'ry roar
Scoops out an empire and uſurps the ſhore.

As may his deſcription of the terrors of that horrid ſhore to which his peaſants emigrate:

Theſe blazing ſuns that dart a downward ray
And fiercely ſhed intolerable day;
Thoſe matted woods where birds forget to ſing,
But ſilent bats in drowſy cluſters cling;

Thoſe

Thoſe pois'nous fields with rank luxuriance crown'd,
Where the dark ſcorpion gathers death around,
Where at each ſtep the ſtranger fears to wake
The rattling terrors of the vengeful ſnake;
Where crouching tygers wait their hapleſs prey,
And ſavage men more murd'rous ſtill than they;
While oft in whirls the mad Tornado flies
Mingling the ravag'd landſcape with the ſkies.

This paſſage is more peculiarly in Goldſmith's manner, the ſublimity here being only an accidental inſtrument to heighten the pathos.

For denſe and ſolid ſentiments — couplets pregnant with ſound reflection in forcible language, fitted to impreſs themſelves on the memory, and to incorporate in the maſs of popular morals, we in vain look in this author's writings. His moral paſſages are too diffuſe for quotation: they are long addreſſes to luxury or to freedom, connected details of the evils of faction, whole ſcenes deſcriptive of city profuſion and rural devaſtation, without any effort to concenter their force in one ſtrong apothegm, or to ſum up the particulars in more compact form, and without calling in the ſupport of any acknowledged and inſtructive truth, delivered in abſtract preciſion and cloathed in impreſſive language. I know but one attempt of Goldſmith's at condenſing the ſubſtance of an antecedent detail, and but one of his couplets containing a moral

ſentiment

ſentiment of ſolid compactneſs. The firſt is the concluſion of a paſſage where the ſplendors of luxury are contraſted with its evils: the peaſant, he ſays, is ſcourged from the ſmiling land,

> And while he ſinks, without an arm to ſave,
> The country blooms—a garden and a grave.

The ſecond is not ſo happy—it is a deſcription of man in a ſtate of early ſimplicity and imagined equality,

> His beſt companions, innocence and health,
> And his beſt riches ignorance of wealth.

It is however evident from the neceſſity of antecedent explication that theſe paſſages are not without ſome violence detached from the context, and therefore even theſe are not well adapted for popular quotation.

But Goldſmith is not a didactic—he is a deſcriptive poet. And many of his deſcriptions cannot be praiſed too highly. The circumſtances in his natural ſcenes are ſelected with peculiar propriety, and painted in the moſt glowing colours. His views of Italy and Switzerland in his Traveller cannot be excelled. His deſcription of Auburn in its deſerted ſtate would have redeemed an ordinary poem.

> No more thy glaſſy brook reflects the day,
> But choak'd with ſedges works its weedy way:
> Along thy ſhades, a ſolitary gueſt,
> The hollow ſounding bittern guards its neſt:

Amidſt

Amidſt thy deſert walks the lapwing flies
And tires their echo's with unvaried cries:
Sunk are thy bowr's in ſhapeleſs ruin all
And the long graſs oe'rtops the mould'ring wall.

Here we have a highly poetical delineation of every adjunct of a deſolated country, with appropriate epithets to add to the force of the effect, and the *bowers* and *glaſſy brook* from its former ſtate remembered to heighten the deſcription by their contraſt.

Such is the general tenor of Goldſmith's deſcription of natural ſcenes. His deſcriptions are by continued enumeration of admirably ſelected circumſtances—each in itſelf expreſſive but the aggregate of inſuperable force. Sometimes however, where he does not allow himſelf to dwell on particular circumſtances, or to embelliſh them by any thing more than a ſingle epithet, the enumeration is but a tame catalogue of beings or of properties, and the deſcription, accurate indeed, but flat and feeble. Take an example from his picture of Holland:

While the pent ocean riſing o'er the pile
Sees an amphibious world beneath him ſmile;
The *ſlow canal*, the *yellow-bloſſom'd vale*,
The *willow-tufted bank*, the *gliding ſail*,
The *crouded mart*, the *cultivated plain*,
A new creation reſcued from his reign.

Left

Leſt it might be thought the poet's judicious art to give a ſtudied tameneſs to the deſcription of the country of Holland, I muſt ſubjoin another inſtance where it certainly was not his object to depreſs his poetical merits to an humble level with his ſubject :

> How often have I paus'd on ev'ry charm
> The *ſhelter'd cot*, the *cultivated farm*,
> The *neverfailing brook*, the *buſy mill*,
> The *decent church* that top'd the neighb'ring hill.

Or this,

> Far different theſe from ev'ry former ſcene,
> The *cooling brook*, the *graſſy veſted green*, &c.

In all theſe the author ſeems ſenſible of the tameneſs of the deſcription, and endeavours, with bad effect, to relieve it by the pompous ſolemnity of his compound adjectives.

But the truth is what Goldſmith has himſelf told us in his dedication of the Deſerted Village to Sir Joſhua Reynolds, " that he was ignorant of that art in which his friend excelled." He has therefore no idea of pictureſque effect. He marks no diſtances in his ſcenes—he ſtudies no arrangement of his objects—he enumerates what a fertile fancy and an exact judgment would ſuggeſt, but the painter who ſhould follow him would have their entire diſpoſition to make out. The writings of Mr. Maſon compared with Doctor Goldſmith's ſhew of what importance the knowledge of the ſiſter art is to a poet.

The

The deſcriptions of life and manners, of national characters in his Traveller, of profeſſional in his Deſerted Village, and of individual in his Retaliation, are drawn with maſterly ſkill. Goldſmith wrote from actual obſervation with the moſt judicious ſelection. His accounts are faithful and characteriſtic ſketches of the hiſtory of man. The ſports of Auburn are deſcribed with the accuracy of an actual ſpectator and with the feelings of one who had partaken of ſuch *. The character of the French peaſantry is given *con amore*. Goldſmith in the moſt endearing and affecting taſte of true paſtoral poetry gives us ſimple manners which yet agree with exiſting nature and humble life remote from vulgarity. Whatever might degrade or diſguſt is carefully concealed, whatever could amplify is without apparent reſearch produced. In the deſcription of the village ale-houſe, the importance which it adds to the poor man's heart is dwelt upon, and the oblivion of his care, but the idleneſs, the intoxication

* Mr. Anderſon in his criticiſm on Goldſmith prefixed to his edition of his works among the Britiſh poets, makes the following obſervation : " The village " diverſions are perhaps inſiſted on with too much prolixity and amplification. " But we are recompenſed for this generality and redundance by the claſſical and " beautiful particularity and conciſeneſs of the context—the dancing pair, the " ſwain miſtruſtleſs—the baſhful virgin," &c. This obſervation is very nearly ſaying that we are recompenſed for Goldſmith's *generality* by his *particularity*, and for his *redundance* by his *conciſeneſs*.

the quarrels are kept judiciouſly from our view. His deſcription of the occupations of the Swiſs peaſant is a maſter-piece:

> Chearful at morn he wakes from ſhort repoſe,
> Breaſts the keen air and carols as he goes;
> With patient angle trolls the finny deep,
> Or drives the vent'rous ploughſhare to the ſteep;
> Or ſeeks the den where ſnow-tracks mark the way,
> And drags the ſtruggling ſavage into day.

No one ſpecific circumſtance of hardihood has eſcaped him, and ſcarcely a ſingle word occurs in the paſſage which does not add appropriate energy. The ſounds in the village evening and the furniture of the ale-houſe deſerve the ſame praiſe.

When Goldſmith has not leiſure to give a compleat deſcription, where by a few particulars a general propoſition is to be impreſſed, thoſe which he ſelects are always the beſt fitted for their purpoſe. Thus where the vanity of the French is to be exhibited Goldſmith ſays,

> Here vanity aſſumes its pert grimace
> And trims her robes of frize with copper lace,
> Here beggar pride defrauds her daily cheer
> To boaſt one ſplendid banquet once a year.

Where the pleaſures of the luxurious are to be deſcribed as ſickening into pain the particulars which our author's admirable ſelection ſpecifies are the *long pomp* and the *midnight maſquerade*. But

But one of the greateſt beauties of Goldſmith's deſcriptions is the embelliſhment of his landſcapes by his figures. Every ſcene with him is alive, and even deſolation is made more affecting by the *ſad hiſtorian of the penſive plain* whom he introduces. This is the great art of intereſting the reader: we may contemplate with pleaſure or with ſurprize inanimate nature, but our feelings are for man. The landſcape in return may by its aſſociations reflect congenial impreſſions, and of ſuch Goldſmith takes advantage in the beginning of his Deſerted Village, where the enumeration of affecting objects of ruin and decay naturally gives a melancholy caſt to the mind. It is idle then to complain, as has been done, that our pity is there excited for what cannot ſuffer—for a brook—or a glade—or a walk—or a wall. We do not feel for the inanimate object: our minds are only pre-diſpoſed by the review of theſe melancholy ſcenes to feel pity for the perſons who are afterwards deſcribed, and our feelings are for the peaſants who have been compelled to emigrate from Auburn. The ſolemn darkneſs of a Gothic cathedral is not religion, but its efficacy to produce an awe on the mind which fits it for the reception of religious impreſſions is indiſputable—and he muſt have none of the verſatility of human fancy or the ſympathies of the human heart who could ſo rivet his attention to the externals of the ſcene of deſolation as not to recur to the condition of thoſe who had formerly been its inhabitants.

The variety of Goldſmith's powers in deſcription of character is perhaps ſhewn moſt ſtrongly in thoſe two which immediately follow each other in his Deſerted Village—the clergyman and the ſchool-maſter. The paſſage in his epitaph "Sive riſus eſſent movendi ſive lachrymæ, affectuum potens at lenis dominator," here comes out an eſtabliſhed truth. If the line

Careleſs their merits or their faults to ſcan,

does not add much praiſe to the clergyman's character; it was however the undiſtinguiſhing liberality for which Goldſmith was himſelf remarkable, and on which he prided himſelf in ſpite of prudence and of propriety. The profeſſional exertions of the clergyman in the diſcharge of his duty, and particularly at the bed of ſickneſs, are recorded in a ſtile of pathetic ſolemnity not to be exceeded. The ſchool-maſter is a contraſt of ſuch oppoſite merit that we might almoſt wonder at its being produced by the ſame hand. Humour cannot produce a picture more rich in the writings of thoſe who could never be ſerious. The affected gravity with which his multifarious learning is produced, the legendary ſtile in which the whole is judiciouſly delivered, and above all the ludicrous circumſtance of ruſtic wonder at the concluſion,

That one ſmall head could carry all he knew

ſhew Goldſmith's powers in this ſtile of poetical compoſition not

not inferior to thoſe which he exhibits in the more ſerious and pathetic. The character of the ſchool-maſter, and deſcription of the village ale-houſe to which he conducts the poet, are genuine productions of that pen which had given to the public the Citizen of the World and the Vicar of Wakefield.

In pathetic images and deſcriptions his Deſerted Village abounds, and it is peculiarly the merit of Goldſmith that he affects us only where we ought to be affected. He does not by any overſwoln amplification of minuteneſſes, by any trick of inſtant vehemence, or by any delineation of the grievances of hypochondriac ſenſibility ſuddenly excite an emotion, of which when we come to conſider its cauſe we are aſhamed. He improves our morals by making us ſympathize with genuine unequivocal affliction: he ſettles habits of uſeful and permanent impreſſion, for he makes us feel for domeſtic diſtreſs—for the fair who is forſaken, and the family which is forced to brave the horrors of emigration.

> When the poor exiles every pleaſure paſt
> Hung round the bow'rs and fondly looked their laſt,
> And took a long farewell and wiſhed in vain
> For ſeats like theſe beyond the weſtern main,
> And ſhudd'ring ſtill to face the diſtant deep
> Return'd, and wept, and ſtill return'd to weep.

The ſubſequent deſcription of the individuals abounds with the higheſt ſtrokes of Goldſmith's powers in the pathetic.

The

The great praiſe of all our author's compoſitions ſerious or comic, in proſe or verſe, is that every thing appears eaſy, ſimple and natural—without any affectation, and with little appearance of effort or labour. This ſeems extraordinary as to his poems, when we are told his particular mode of compoſition. "He uſed," ſays one of his biographers, "firſt to ſketch out a part of his "deſign in proſe, after which he ſat down carefully to verſify "what he had written, to correct it and to add ideas better ſuited "perhaps to the ſubject." From his view of his materials antecedent to their final and eſtabliſhed arrangement we might expect a judicious general method, and ſuch we actually find; but we might alſo expect that his mode ſhould leave behind it traces of labour and artifice—the advantages of accuracy and the ſtiffneſs of ſtudy. His works on the contrary exhibit no marks of art—his verſe ſeems to contain his firſt thoughts in his firſt expreſſions. The reaſon of this we may perhaps find in the author's character. His vanity had ſo ſtrong an attachment to what he had once written that his poems in all probability differ but little either in ſubſtance or in order from their proſaic elements. It is true Goldſmith's later editions alter many paſſages in his earlier ones, but the reluctance with which he had parted with his former has uſually made his corrections in the latter incomplete, and has left the corrected paſſages at laſt but a ſort of tiſſue between what they were and what they ought to be.

Or

Of his fondneſs for his own writings we have an unequivocal proof in the frequency with which he borrows from himſelf. Sentiments occur in his plays expreſſed in the very ſame words as in his Vicar of Wakefield. The lengthening chain which he drags in his Traveller, as he removes from his brother, connected the Chineſe philoſopher with his friend in the Citizen of the world. The excellent furniture with which he has decorated his village ale-houſe belonged formerly to Scroggen the hackney author whom Goldſmith had before deſcribed. The couplet in his Deſerted Village

> Along the lawn where ſcattered hamlets roſe
> Unwieldy wealth and cumbrous pomp repoſe,

is almoſt a tranſcript of the following in his Traveller

> And over fields where ſcatter'd hamlets roſe
> In barren ſolitary pomp repoſe.

And of that ſublime paſſage already quoted which deſcribes the horrors of the weſtern clime we have the original in the Traveller, where

> the pilgrim ſtrays
> Through tangled foreſts and through devious ways,
> Where beaſts with man divided empire claim,
> And the brown Indian marks with murd'rous aim.
> There while above the giddy tempeſt flies
> And all around diſtreſsful yells ariſe, &c.

Passages of ſuch ſimilarity in ſentiment and expreſſion certainly ſhew the peculiar fondneſs with which Goldſmith looked on any work which he had once given from his hands, and which ſo chained down his imagination to one mode of conſidering a ſubject that whenever that ſubject recurred the author could not view it but in the very ſame light. Goldſmith however appears ſometimes to have caught the ſame fondneſs for ſentiments which had been expreſſed by other authors, and, as if unconſcious of their original, delivers them in their identical words and forms of ſpeech. Pope has the following couplet:

> To ſavage beaſts and ſavage laws a prey,
> And kings more furious and ſevere than they,

the laſt line of which is of the very ſame ſtructure with one of our author's quoted in page 83. And no perſon can be prevailed on for a moment to imagine that there is not ſomething more than a caſual coincidence between Goldſmith's

> Man wants but little here below
> Nor wants that little long,

And Young's,

> Man wants but little, nor that little long.

Surely the author who could borrow with ſo ſlender artifice could not ſuſpect himſelf of plagiariſm and muſt have miſtaken the treaſures of his reading for the conceptions of his fancy.

This

This identity of phraſe on the recurrence of the ſame ſubjects certainly indicates a ſcantineſs in Goldſmith's vocabulary. He has alſo favourite words and forms which ſhew themſelves in every page. We have the unfeeling *train*, and the lowly *train*, and the vagrant *train*, and the harmleſs *train*, and the buſy *train*, and the lovelieſt *train*, and the gorgeous *train*, all in the Deſerted Village.—We have within its firſt ſeventeen lines the author loitering over *the green* of Auburn—and deſolation ſaddening *all its green*, and the healthful ſports which formerly brightened *all its green*. We have the friend *crowned*, and the glaſs *crowned*, and the board *crowned*—all very looſe and indefinite ſignifications of the word. We have colloquial phraſes, *ſit me down*, —*once a year*—*many a time*—*times are altered*. We have weak words, adverbs and prepoſitions often filling up his verſes.—All theſe are careleſs faults which a little attention might have rectified, and founded perhaps in too great a love of ſimplicity and deſire to be familiar.

Goldsmith's diction both in verſe and proſe is extremely eaſy—in ſome places perhaps to negligence. His Traveller begins with ſeveral adjectives ſtrung together,

Remote, unfriended, melancholy, ſlow,

while the ſubſtantive to which they belong does not appear until the ſeventh line. He is not ſtudious of writing with the exactneſs of a grammarian, and therefore ſometimes uſes

preſent for paſt times, ſometimes paſſive for active participles: ſometimes he even gives us paſſages wholly independent of regular connection in the conſtruction of the ſentence, as in his deſcription of the Dutch in his Traveller,

> At gold's ſuperior charms all freedom flies,
> The needy ſell it and the rich man buys;
> *A land of tyrants and a den of ſlaves,*
> Here wretches ſeek diſhonourable graves.

In this paſſage however, and in all of this ſort, it is but fair with reſpect to our author to ſtate that his meaning is not at all obſcure. Goldſmith's conſtructions rarely lead to obſcurity or ambiguity *. Like Addiſon he is ſimple and familiar, and like Addiſon he is elegant and intelligible.

As the epithets of other poets have met his cenſure his own are fairly ſubject to animadverſion. His *penſive* plain has been condemned as too bold—I think with little reaſon—with leſs certainly than his *bleak* Swiſs which ſeems more extravagant, his

* There is one form of phraſe uſed frequently by Goldſmith, which, if followed, might in other authors lead to ambiguity—it is the deferring of circumſtances which limit a particular ſubſtantive until other ſubſtantives ſhall have been interpoſed. In the couplet,

> Whatever blooms in torrid tracts appear
> Whoſe bright ſucceſſion decks the varied year,

The bright ſucceſſion ſeems rather to belong, by the conſtruction, to *tracts* than to *blooms*.

his *ſenſual* bliſs which may be miſtaken, or his *plethoric* ill which is technical. He is too fond of compounding new words by the mere inartificial addition of two known ones, as *wave-ſubjected*, *ſhelter-ſeeking*, *rocky-creſted*, and crouding them together until the reader is diſguſted with their monotony. But many of his ſimple epithets have a force of argumentative ſignification and beauty of delicate expreſſion which the pomp of learned ſounds cannot often reach—as in the following lines:

> " The toiling pleaſure ſickens into pain."
> " No buſy ſteps the graſs grown footway tread."
> " Here the pale artiſt plies the ſickly trade."
> " The robe that wraps his limbs in ſilken ſloth."

You have in a ſingle epithet the ſtate of Swiſs morals fully accounted for,

> And love's and friendſhip's finely-pointed dart
> Fall blunted from each *indurated* heart.

And in another epithet you have a complete picture of the Italian ſcenery,

> Its uplands ſloping deck the mountains ſide,
> Woods over woods in gay *theatric* pride.

Thus we ſee that though eaſe and ſimpliciy are the characteriſtics of our author's writings, yet there is no want of ornament in his imagery or of metaphorical graces in his dic-

 tion.

tion. His ſimiles therefore might be expected to be, as indeed they are, beautiful pictures and well adapted illuſtrations. With their acknowledged merits of this ſort they certainly unite one of ſingular ſubtilty. Many of them are local images, the appropriate growth of the ſcene or country which he deſcribes. The mean delights of the modern Italians ſucceeding the nobler aims of their progenitors are illuſtrated by the ſimile of the peaſant ſeeking ſhelter in thoſe domes where Cæſars once bore ſway *. The virtues of the Swiſs are like falcons cowring on the neſt: the Dutch, conformed to ſervitude, are

Dull as their lakes which ſleep beneath the ſtorm.

Such a felicity in his ſimiles embodies them into the main ſubject, and even gives an apparent ſtrength to the theory in his Traveller, by an indirect intimation that the national character is founded in ſome aſſociate circumſtance of the natural hiſtory of each country.

The ſimile in which our author compares the miſer's rapture at the view of his hoards and his ſighs for thoſe which are wanting with the alternate paſſions in his own breaſt, of pleaſure

* The ſame effect is produced by an artifice of Goldſmith's diction. The peculiarity of the word *long-fall'n* as applied to the mind in Italy naturally recals to our view the *long-fall'n* columns in the ſame country which had been mentioned but eleven lines before, and thus induces a mental compariſon between the ſtate of their arts and their minds.

pleaſure at the goods which Heaven has given to man, and ſorrow to ſee the *hoard* of human bliſs ſo ſmall, pleaſes me more than the more celebrated ones of the child clinging

Cloſe and cloſer to the mother's breaſt,

and the circle bounding earth and ſkies which

Allures from far and as he follows flies *.

The cauſe of the child's clinging has no connection with the mother to whoſe breaſt ſhe clings, whereas the loud torrent and the mountains roar is a natural adjunct to thoſe mountains to which the Swiſs peaſant is more firmly bound: and how the horizon allures from far by no means appears. But the two ſimiles which decorate the village clergyman, of the bird tempting its new-fledged offspring to the ſkies, and the tall cliff around whoſe head ſettles eternal ſunſhine, are for endearing intereſt and appoſite beauty unequalled by any of our author, and excelled by very few in the language.

Goldsmith's verſification has been formed with great exactneſs on the model of Mr. Pope. Whoever reads Windſor Foreſt with attention will find the elements of many paſſages in Goldſmith's writings, will diſcover the original in which he ſtudied poetry

* Strange that one of Goldſmith's commentators ſhould ſpeak of this as a ſimile of the *rainbow!*

poetry and from which he caught by congenial feeling the graces of elegant expreſſion and harmonious verſification. Every poem of Pope's contains ſomething, which to a reader who knows our author will recall ſome paſſage in his works by a word or by a conſtruction, by ſome turn of the verſe or of the ſentiment. Goldſmith's verſification is more feeble and more careleſs than Mr. Pope's, but perhaps it is more varied and more ſimple. I cannot avoid quoting one of the ſhorteſt of Goldſmith's poems as a ſpecimen, among many other beauties, of the eaſe of his conſtructions and the harmony of his numbers.

ON MEMORY.

Oh! memory, thou fond deceiver
Still importunate and vain,
To former joys recurring ever,
And turning all the paſt to pain.

Thou, like the world, th' oppreſt oppreſſing,
Thy ſmiles encreaſe the wretch's woe;
And he who wants each other bleſſing
In thee is ſure to find a foe.

In the lines of Goldſmith we have no elaborate equipoiſe between the parts where the latter half is made an epigram upon the former. His only artificial ornament is alliteration which occurs too frequently for us to ſuſpect its being caſual.

He

He continues the ſame thought often beyond the line, and ſometimes beyond the couplet *. Hence it happens that his verſes are natural and their harmony varied, though it muſt be obſerved alſo, that the pauſes in ſound do not always coincide with thoſe in ſenſe. His lines are often eked out by feeble and expletive parts adjoined, ſuch as *more*, *between*, *here*, *ſo*, and ſeveral weak terminations and proſaic verſes might be pointed out in his writings, as where he tells us that the morals of the Swiſs *are but low*—that the train of Auburn at proud men's doors *beg a little bread*—or that nations *though very poor may ſtill be very bleſt*. His rhyming words are generally monoſyllables of the moſt familiar claſs. The word *fire* rhymes in two couplets out of three in his Traveller—the word *round* rhymes three times in eleven couplets in his Deſerted Village. Goldſmith in this reſpect did not ſufficiently conſult variety, but he poſſeſſes thoſe happy arts of engaging the reader's attention to ſome beauty, or intereſting his affections by ſome pathetic image, and the fault which is not perceived is as if it did not exiſt.

Goldsmith's faults are all faults of apparent inadvertence; but would his poems be more excellent had he ſtudied to correct

* This is ſometimes attended with a powerful and ſublime effect.

> Beſide the bed where parting life was laid,
> And ſorrow, grief and guilt by turns diſmay'd,
> The reverend champion ſtood. At his controul, &c.

correct them to greater minuteneſs? He might have arranged his thoughts in regular climax—he might have given us contraſted ſentiments and parallel phraſes—he might have deſtined forcible words to important places — he might have condenſed matter for concluding couplets. But his works would have been elaborate—his diction pompous—his verſification meaſured. He would have forfeited his eaſy ſimplicity. Some readers would not ſo well underſtand him and perhaps none ſo much delight in him. At preſent he is a general favourite, and thoſe who think his excellence is of that common nature which any perſon might reach have only to make the attempt and thus convince themſelves of his merit. Paradoxical as it may ſeem, there is no ſtile of writing more difficult of attainment than that which is natural.

ANTIQUITIES.

A LETTER *from* WILLIAM CAULFIELD LENNON, *Esq; to the Right Honourable the* EARL *of* CHARLEMONT, *President of the Royal Irish Academy, &c. &c. &c.*

My Lord,

PERMIT me to have the honour of presenting you an image taken from a Pagoda in Bangalore, at the storming of that fort in 1791, which, if it proves worthy of a place in the Cabinet of your Academy, I shall consider myself amply recompensed for the trouble of bringing from thence. Read Nov. 15, 1794.

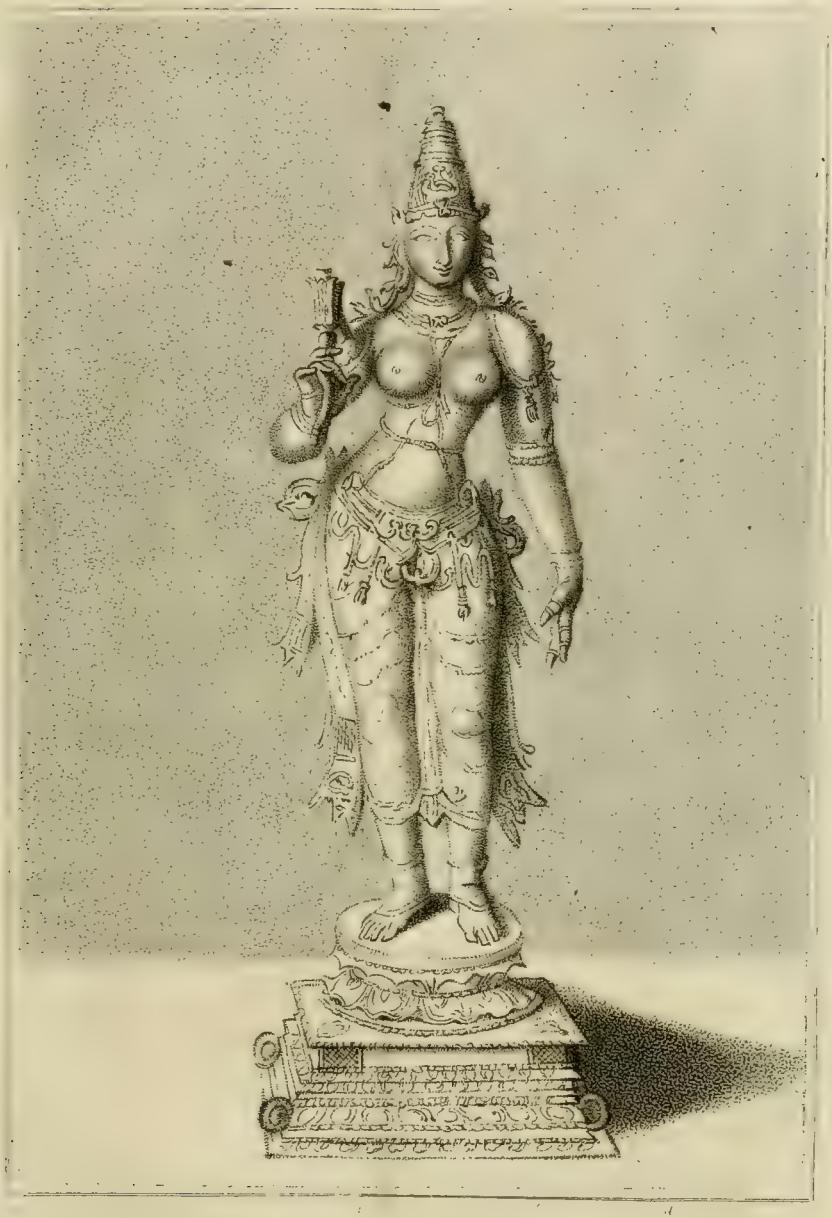
This image represents Letchemy †, the goddess of riches, fertility, beauty, mirth, courage, joy, eloquence and matrimony,

† (Lechemy) The name of this goddess is thus written by Craufurd, in his Sketches of the Hindoos, and by most of the earlier writers: "Lechemy," says Craufurd, "is the "consort of Vishnou, and is the goddess of abundance and prosperity." By Sir William Jones (Asiatick Researches, Vol. I. on the Gods of Greece, Italy and India) she

who from the variety of her power and patronage is ſtyled Mahay Letchemy, or the Great Letchemy. She is the firſt wife of Veeſhnoo, one of the Treemoortee or Hindoo Trinity, to whom ſhe was married under the name of Seddee, when that god manifeſted himſelf to the world under that of Rama, at the court of her terreſtrial father Tiſſeradah Rajah. She is equally worſhipped in all the pagodas or temples both of Shivven and Veeſhnoo, the former of whom is the chief and moſt powerful of the Treemoortee. Bruma, the third in conſequence and power, has no temples of worſhip erected to him. She is repreſented in the habit of a Cunſhinnee or dancing girl, as the goddeſs of mirth and beauty: the flower ſhe holds in her right hand is the Taumaray or Indian Lotus, which grows in all the tanks or reſervoirs of water, and is the emblem of fertility, as it only grows in water, on which all fertility in that country depends.

THE

ſhe is called *Lacſhmi*, and is by him ſuppoſed to be the *Ceres* of *Hinduſtan*, her moſt remarkable name being *Srí*, or in the firſt caſe *Srís*.—"It may be contended," continues he, "that although Lacſhmi may figuratively be called the Ceres of Hinduſtan, yet any two or more idolatrous nations, who ſubſiſted by agriculture, might naturally conceive a deity to preſide over their labours, without having the leaſt intercourſe with each other; but no reaſon appears why two nations ſhould concur in ſuppoſing that deity to be a female: One at leaſt of them would be more likely to imagine that the earth was a goddeſs, and that the god of abundance rendered her fertile. Beſides, in very ancient temples near Gaya, we ſee images of Lacſhmi with full breaſts, and a cord twiſted under her arm like a horn of plenty, which look very much like the old Grecian and Roman figures of Ceres." This goddeſs is alſo named Pedma and Camala.



The metal of which this and the generality of images in India are formed is compoſed of the free offerings of the votaries who attend the pagodas at certain times. Of the different coins, pagodas which are gold, rupees ſilver, and dubs or doodies copper, when the bramins of the pagoda have got the quantity neceſſary, the whole is melted together and caſt into the deſired form; the natives of India being particularly ingenious in compounding metals of different qualities.

The leaf which accompanies the image is the Cadjan or Palmyra* leaf, on which the Hindoos write with an iron ſtyle. The writing on it is a fable in the Tamoul or Malabar language, a tranſlation of which I obtained from my friend Mr. Kinderſley, author of Specimens of Hindoo Literature, which I alſo take the liberty to ſend, and hope it may prove acceptable.

I have the honour to be,
My Lord,
Your Lordſhip's moſt obedient,
And very humble ſervant,
W. CAULFIELD LENNON.

Dublin, Auguſt 1, 1794.

* (Palmyra) A ſpecies of the palm tree, of which there are three kinds in India; of theſe the moſt eſteemed is the Cocoa, the next in eſtimation is the Palmyra, and the leaſt valuable is the Date Tree.

Fable of the Jackall and Drum.

IF the waters of your fears ſwell immoderately the banks of your fortune will be broken. When fortitude fails no ſucceſs is to be expected. What appears moſt terrible may prove an empty ſound.

Two hoſtile Rajahs having engaged in battle one of them was routed, and among other articles his troops left on the field of battle a drum. A neighbouring jackall, attracted by the ſcent of the blood, came to the ſpot, and had already, in imagination, devoured the ſlaughtered elephants and horſes around him, when his attention was arreſted and his alarms excited by the ſound of a drum. At firſt fancying the Rajahs were returning to battle, he prepared, however reluctantly, to decamp, but the noiſe ceaſing he ventured to approach the ſpot whence it proceeded; when diſcovering that it aroſe from the wind occaſionally ſtriking a branch, which hung looſe from a tree, againſt the drum, he paſſionately tore the cauſe of his terrors, and turning to the banquet before him quietly enjoyed his good fortune.

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An ACCOUNT *of ſome* MANUSCRIPT PAPERS *which belonged to* SIR PHILIP HOBY, KNIGHT, *who filled ſeveral important Offices in the* REIGN *of* KING EDWARD *the* SIXTH, *and which are at preſent the Property of* WILLIAM HARE, ESQ; *one of the Repreſentatives in Parliament for the City of Cork; by the Reverend* MR. HINCKES *of Cork, communicated by the* PRESIDENT.

Read December 17th 1796.

THE deſire which mankind have ever felt to be acquainted with the proceedings of their anceſtors, and the important advantages which may be derived from hiſtorical knowledge, have cauſed great attention to be paid to all the various ſources of hiſtorical information. Amongſt theſe ſources, public acts of the government, and the private as well as public correſpondence of individuals, whoſe great knowledge or peculiar ſituation gave them an opportunity of being acquainted not only with events, but alſo with the cauſes of them, have ever held a principal place; and all good compilers of hiſtory have carefully conſulted ſuch as could be found in public libraries, or in thoſe offices of ſtate appointed

appointed for their reception. The correſpondence of an ambaſſadour reſiding at a foreign court with the government at home muſt be particularly uſeful in this view, becauſe the letters addreſſed to the ambaſſadour would contain an account of important tranſactions at home with the cauſes of them, to enable him to ſet them in a favourable light abroad; and the letters of the ambaſſadour would contain not only an account of all his tranſactions with the prince at whoſe court he was a reſident, but alſo all the intelligence he could procure relating either to that court or others, his own opinion concerning them, and what he underſtood to be the *general* opinion. This was more neceſſary, and therefore was probably more common, in times when there were no newſpapers, or frequent communication by letters, than at preſent, when means of information lie open to every individual. In the correſpondence of an ambaſſadour from England to a maritime power, ſome information reſpecting the ſtate of commerce may alſo be expected, becauſe complaints would frequently be made which would demand his attention. Even letters from private perſons, whether of eminence or not, are intereſting, when written long before our own time, becauſe, though only complimentary or ſupplicatory they muſt throw ſome light on the manners and cuſtoms of the period in which they were written.

The ſtate of the language and the autographs of eminent perſons are alſo uſeful, not merely to gratify the curioſity of the antiquarian, but alſo to prevent the forgery of writings in the name of ancient authors by rendering the detection of it more eaſy.

It

It was by an accurate knowledge of the mode of writing and ſpelling when Shakeſpear lived, by comparing the pretended hand-writing of Queen Elizabeth and others with their real autographs, and by pointing out ſeveral variations from the manners and cuſtoms of that period, that an eminent critic was able completely to detect the late forgery of manuſcripts in the name of Shakeſpear, which at firſt impoſed upon many literary men. Thus did his reſearches into the manuſcripts and publications of the Shakeſpearian age enable this gentleman to preſerve uncontaminated the productions of a poet who is his country's pride, as they had before enabled him to illuſtrate them in a more ſatisfactory manner than any of his predeceſſors.

Since ſuch advantages may be derived from an acquaintance with manuſcript papers of paſt ages, it becomes a duty incumbent upon thoſe who meet with ſuch remains of antiquities as have continued in private families, either to publiſh copies of them if they prove ſufficiently intereſting, or at leaſt to ſignify the contents of them, and where they may be conſulted for the information of thoſe whoſe purſuits may be aſſiſted by a peruſal of them.

With this view it is intended in the preſent Eſſay to give an account of ſome papers which belonged to Sir Philip Hoby, ambaſſadour from King Edward the ſixth to the Emperor Charles the fifth, which are contained in two volumes folio, at preſent the property of William Hare, Eſq; M. P. for Cork, by whom they

they have been obligingly lent to the writer with full permiſſion to communicate the contents of them in whatever manner he pleaſes.

Sir Philip Hoby ſeems to have been firſt introduced to the public by Biſhop Burnet in his hiſtory of the reformation, a work founded upon a very laborious inveſtigation of all the papers he could find in the public libraries or offices to which he had acceſs relating to the period concerning which he wrote. It is now well known that Sir Philip filled the poſt above-mentioned during part of the reign of Edward the ſixth, and alſo that he was employed in other commiſſions of importance. One of the volumes of manuſcript papers which are the ſubject of this eſſay conſiſts principally of letters to Hoby from the Protector and council and from eminent private characters, all of which are *original;* it alſo contains ſome original ſtate papers with copies of others, and alſo copies of ſeveral foreign papers, as will appear from the liſt of the contents which is annexed. The other volume conſiſts entirely of copies of letters written by Sir Philip Hoby to the Protector and council whilſt a reſident at the imperial court. Theſe letters are not confined to the reign of Edward the ſixth, the earlieſt date being in 1539 and the lateſt in 1556; the greateſt part were however written in 1548, 1549 and 1550.

By what means theſe volumes firſt came into Mr. Hare's family cannot now be exactly aſcertained, nor can it be of any importance

importance as the proofs of their authenticity are ſufficiently ſtrong. It may however deſerve notice that the reverend Sir Philip Hoby, Baronet, who died in the year 1766 Dean of Ardfert, was a lineal deſcendant of Sir Edward Hoby, Knight, the nephew and heir of the ambaſſadour. By his death the title of Baronet conferred in 1666 became extinct, but there is an account of the family in the firſt edition of Collins's baronetage. That the papers were firſt collected and bound together by Sir Edward Hoby is probable from the initials E. H. which are marked on one ſide of each volume.

In proof of the authenticity of theſe papers it may be obſerved that Biſhop Burnet *(a)* mentions ſuch a collection which he had ſeen from which he took extracts, and the whole of which he would have publiſhed if it had been in his power. Some of the letters mentioned by Burnet have been found in the manuſcript collection, but reſpecting one he ſeems to have fallen into an error, a circumſtance very excuſeable when it is conſidered how he was circumſtanced. From thoſe which have been found, it is however very probable, if not certain, that the manuſcripts belonging to Mr. Hare are the very ſame which the Biſhop met with. There are alſo two letters written by Hoby and Sir William Paget jointly, found by Burnet in the Cotton library, copies of which and of ſome others on the ſame ſubject are in

(a) Hiſt. of Reform. Vol. iii. p. 133, 134.

theſe volumes, and differ very little (except in the ſpelling, which the Biſhop muſt have moderniſed) from thoſe found in the appendix to Hiſt. of Reform. Vol. II. p. 135.

It may be further remarked that the manner of forming the letters, the ſpelling, and the ſtile are ſimilar to thoſe of authentic remains of that age; which may alſo be obſerved of the mode of directing and folding the letters, the ſize of the ſeal, and the water-marks of the paper, which latter vary according to the country from which the letters were written. The ſignatures of Archbiſhop Cranmer, Biſhop Gardiner, Martin Bucer, John A Laſco and others agree with facſimiles of their handwriting which have been already publiſhed *(b)*. The titles uſed by the King in ſeveral of the ſtate papers are alſo agreeable to the uſage of that period, as ſtated by Biſhop Nicholſon *(c)*.

To eſtabliſh however the authenticity of theſe papers as much as poſſible, they were ſubmitted to the inſpection of ſeveral literary gentlemen in this kingdom, and amongſt others to that of the preſident and members of the Royal Iriſh Academy; and alſo to that of Thomas Aſtle, Eſq; of the paper-office, Whitehall, a gentleman well known in the literary world as the author of a curious

(b) In the appendix to Dr. Jortin's life of Eraſmus.

(c) Eng. Hiſt. Library, Part iii. ch. i. p. 145. quarto edition.

a curious and valuable work *on the origin and progreſs of writing*, and of Edmond Malone, Eſq; the former of whom from his general knowledge of antiquities and his peculiar means of information, and the latter from his having paid ſuch particular attention to all writings and manuſcripts near that period with a view to elucidate his favourite author, ſeemed evidently qualified to give a deciſive opinion *(d)*. Both theſe gentlemen were ſo obliging as to take the trouble of inſpecting them, and declared that no doubt could be entertained of their being genuine and authentic papers. Mr. Aſtle, alſo very politely cauſed a ſearch to be made in the paper-office, which enabled him to inform the writer that none of Sir P. Hoby's letters to the council nor more than one copy of a letter to him are to be found there, a circumſtance which muſt render theſe volumes of more importance than they would otherwiſe be.

HAVING thus ſtated the reaſons for believing the authenticity of theſe papers, a conciſe account of the contents will be added as the beſt means of enabling the reader to judge of their importance.

(d) The writer was indebted to the Right Honourable the Earl of Charlemont, Preſident of the Royal Iriſh Academy, for an introduction to Mr. Malone, and to the Right Reverend the Biſhop of Limerick for one to Mr. Aſtle; favours much enhanced by the very obliging manner in which they were conferred.

To ſome other members of the Academy as well as to other gentlemen he owes ſimilar obligations.

Volume containing original letters, ſtate papers, &c.

1539. INSTRUCTIONS from King Henry eighth to Sir T. Wyat and Mr. Hoby, ordering them to repair to the Emperour Charles the fifth at that time in Spain, and adviſe him on the ſtate of his affairs; of which a view is taken, and a cloſe alliance with England recommended. The principal object of this embaſſy was to ſettle the terms of a marriage between Henry and the Ducheſs Dowager of Milan, Charles's niece; and between the Princeſs Mary and a Prince of Portugal, to whom the Emperour was urged to give the Milaneſe.

A LETTER from Wyat to King Henry

MEMORANDUM from Wyat to Hoby on his return.

BOTH theſe relate to the ſame buſineſs and contain the Emperour's anſwer, &c.

MEMORANDUM of remarkable events.—written at Toledo.

LETTER from Lord Crumwell to Hoby, ordering him to go to France and viſit the daughters of the Dukes of Guiſe and Lorrain, take their likeneſs, &c.

A FRAGMENT of a letter on the ſame ſubject.

1546. AN order of council to Hoby to appear and anſwer ſome charges againſt him ſigned by Wriotheſly, and Gardiner, Biſhop of Wincheſter.

1548 to 1553. TWENTY-SIX letters from the council during the Protectorate of the Duke of Somerſet and four letters after his depoſition, all original, and containing the *autographs* of almoſt every member of the council—viz. of the Dukes of Somerſet, Northumberland and Suffolk, the Marquiſſes of Wincheſter and Northampton, Earls of Southampton, Bedford, Arundel and Pembroke, Lords Seymour, Rich and Paget—Biſhop of Ely, Chancellor, Cranmer Archbiſhop of Canterbury, Sir T. Smith, Sir W. Cecill, Petu, Wotton, Hampton, &c. Some of theſe letters contain important information, whilſt others are merely orders for hiring foreign troops, ſending ammunition, or on other official matters. Copies of all advices from Scotland, with which kingdom the Engliſh were then at war, are annexed to theſe letters, and are curious as giving the detail of the military tranſactions, and as being the *only* court gazette in thoſe times.

FIVE letters from the Duke of Somerſet.

Two ditto from the Duke of Northumberland.

ONE ditto from Duke of Bedford and others ſent ambaſſadours to France, dated Boulogne, March 1549, giving an account of the peace they had juſt concluded with France.

Two ditto from the famous Cecill, afterwards Lord Burleigh, one of them an entire autograph written in great agitation in the interval between the death of King Edward and the proclamation of the Lady Jane Gray.

THREE

THREE letters from Sir William (afterwards Lord) Paget.

Two letters from Sir R. Morryſon, ambaſſadour at the imperial court.

ONE ditto from Mr. Vane, ambaſſadour at Venice.

THREE ditto from the celebrated Sir John Cheke.

Two letters from John A Laſco.

THREE dittto from Martin Bucer.

ONE ditto from Maurice, Elector of Saxony.

ONE ditto from the Duke of Ferrara.

ONE ditto from Monſieur de l'Odenie, a French ambaſſadour.

FOUR ditto from Pietro Aretino, the laſt incloſing two ſonnets on Philip prince and afterwards king of Spain.

THERE are ſome other letters from perſons not ſo well known, and many articles of intelligence, written chiefly in Italian, from Conſtantinople, Rome, Venice, &c. which Hoby procured to tranſmit to England.

A PASSPORT on vellum ſigned by the King.

AN account of the expenſe attending three hundred horſe.

COPY of a warrant to Sir E. Peckham, ordering him to pay ſome money to Hoby.

PASQUILLUS

PASQUILLUS GERMANICUS; intended to ridicule the interim.

REFORMATIO CLERICORUM; copy of a paper publiſhed in Germany about the time of the interim.

ACTA AUGUSTAE. 14 Junii 1548.

COPY of a long letter from Sir W. Paget, maintaining the right of the Engliſh ſubjects to a river which was diſputed by the Duke of Anchot, a ſubject of the Emperour's, whoſe territory joined the county of Guiſnes, at that time ſubject to England.

COPY of propoſitions made by the Duke of Lorrain and Bar to the diet at Augſburg reſpecting privileges.

COPY of a proclamation made by a French herald in the Emperour's court reſpecting juſts at Paris.

1549. COPY of a very long letter written by a Milaneſe Gentleman to his friend the Marquiſs de'Soncino, giving an account of ſeveral entertainments at the Emperour's court in Flanders.

EDICT of Pope Julius III. againſt the Lutherans.

COPY of a letter from King Edward to the Queen Dowager of Hungary, regent of the Netherlands, in behalf of Mr. Chamberlain his ambaſſadour to her court.

A REMONSTRANCE from ſeveral Engliſh merchants to the Emperour.

Two

Two petitions reſpecting ſhips which had been captured by the Emperour's ſubjects.

Two memorials reſpecting ſimilar captures.

Copy of a letter from the council to Thomas Greſham, (afterwards diſtinguiſhed in Queen Elizabeth's reign) reſpecting the borrowing and paying of money for the King in 1551.

Instructions to Sir P. Hoby to pay money for the King. This paper is original and has the King's ſignature.

An account of the money as laid up in purſes.

A paper containing a reckoning of the money.

An acquittance ſigned by ſeveral members of council, given to Hoby as a proof of his having paid the money.

An acknowledgment from the mayor of London of his having received the city's bond for the money, the corporation of London having joined with the King in giving ſecurity to the lender.

Copy of a bill wherein Sir P. Hoby and Mr. Greſham are bound for ſix thouſand pound taken up by them for the King's uſe.

A passport ſigned by the Queen Regent of the Netherlands.

A memorial of grievances committed by the Emperour's ſubjects, ſigned by ſeveral members of the council. (*Original.*)

Instructions

INSTRUCTIONS given to Hoby as ambaſſadour extraordinary founded on the preceding grievances. (Original with the King's ſignature.

A SUMMARY of the preceding inſtructions.

A LIST of money and jewels which belonged to the Dutcheſs of Somerſet, and copies of confeſſions made by the Ladies Margaret and Jane Seymour, Lady Tyrrell and Chriſtopher Dunn reſpecting them.

COPY of the commiſſion given to Sir P. Hoby in conjunction with others of the council to hear requeſts.

COPY of a commiſſion for the ſale of charity lands in 1552.

EXAMINATION of Lady Suſſex reſpecting ſome prophecies which had been rumoured in 1552.

COPY of inſtructions given to Sir A. Dudley ſent Ambaſſadour to the Emperour in December 1552.

INSTRUCTIONS given to the Biſhop of Norwich, Sir P. Hoby, and Sir R. Moryſon, Ambaſſadours to the Emperour, 1553.

COPIES of inſtructions given at two different times to the Marquiſs of Northampton, Hoby and others, ſent to France, reſpecting the marriage of the King with the Princeſs Elizabeth of France, relating to the dowry, &c.

Sir P. Hoby's charge for expenſes on this embaſſy to France, ſpecifying the different articles.

Copy of the Marquiſs of Northampton's teſtimony of the fairneſs of the charge—of the King's order for payment and of Hoby's receipt.

Inventory of jewels, veſtments, &c. in the collegiate church at Windſor.

Various depoſitions, petitions, &c. from the dean and chapter relating to the ſale of the jewels and the diſpoſal of the money received for them.

A Diet, or manner of living preſcribed for Sir P. Hoby at ſome baths in Germany in 1554.

Il proceſſo del duello, a long Italian paper dated December 1554.

Copy of the Elector of Saxony's reply to the King of Bohemia reſpecting the prorogation of the diet in 1555.

Account of a treaty between the Emperour and King of France in 1556, with the names of the ambaſſadours of the princes included on each ſide, &c.

The

The other Volume contains

COPIES of ninety letters written by Hoby to the Protector between 11 May 1548 and 19 September 1549, ſoon after which he returned to England for a few weeks, and was there when the Duke of Somerſet was deprived of the protectorate.

COPIES of thirty-nine letters written to the lords of the council after his return to the imperial court, beginning 10 November 1549 and ending 28 October 1550.

THESE letters, many of which are very long, contain accounts of his converſations with the Emperour and his miniſters; of the tranſactions of the imperial court; of the intelligence received there, and of the opinion entertained by the courtiers of Engliſh affairs, which laſt topick ſometimes introduces his own opinion and advice.

SUCH are the contents of the two volumes which have been the ſubject of this eſſay. It is not probable that they will diſcover any event of importance; yet they may probably throw light upon the cauſes of ſome which have been the ſubject of controverſy, and particularly the ſurrender of Boulogne, and they cannot fail to entertain thoſe who love hiſtorical detail, and thoſe who are curious to know what was thought of tranſactions by perſons then living, and the conjectures which were formed reſpecting events that had not taken place.

[The direction of the following letter has been torn off and loſt; it is in the hand-writing of Sir John Cheke, and is ſigned by him and Sir Thomas Wroth, who was alſo engaged in educating the young king. With reſpect to the Scotch intelligence in the poſtcript, it may be obſerved that on comparing it with the extracts from the official letters which occur in another place it appears to be exaggerated.]

WHAT an ungracious chanſe have yow, mi lord ambaſſadour, y^t^ whileſt Englond was il, and Germanie good ye remained here to ſee thinges ye wold not, and now Germanie groweth to the worſe, and we to ye better, ye flie from Englond to Germanie, as though ye could dwel no where but where good thinges appaire *(a)*. If it be yor nature to make the contree ſo, we mai be glad of your departinge, and deſire ye mai go embaſſadour, ſom other whither, to goddes and the kinges enemies. If ye goodneſs of ye contree when it is amendinge drive you awaie, we muſt nedes take yow to be ſum diſeaſes ſonne, other *(b)* ye gontes or the ſtones or the fever quartaines, or els ſume megre and drie agues childe, y^t^ can not abide in ye contree when y^e^

holſome

(a) appaire. This word is now obſolete and is not to be found in any dictionary I have met with. It ſeems, however, to have the ſame meaning with *impair*, derived from the French *empirer*, which was uſed by Spenſer in a ſimilar manner.

" Fleſh may impair, quoth he, but reaſon can repair."

See Dr. Johnſon on the word.

In like manner *appeach* and *appeachment* have the ſame ſignification with *impeach* and *impeachment*.

(b) other. This muſt have been intended for *ether*.

holſome ſeaſon of true religion is come. But howſoever and whereſoever god go forward, it is mooſt fit for yow now, to lie, to diſſemble, to make a good face if ye had it of all thinges, and ſhew yor ſelf to be a man and no angel, and a ſerver of tornes and no trueth. Wel this for yow, ye require now how we doo, verie wel we thanke yow, and thanke ye for yor lettres, being ſorie for yor interim *(c)*, and deſiring a ſemper, for ye word of godde remaineth for ever, and ſuer there was never ſo good an interim, for it is an interim in dede, and nothing but an interim, for while the graſse groweth ye hors ſtarveth, ye aſk how, even with y^{t} famin of the worde y^{t} ye prophete Jeremie ſpeketh *(d)*. but ye lord is pacient and abideth y^{t} uttermoſt plunge, and y^{en} wil ſodainlie ariſe, and ether overthrow his adverſaries to his glorie, or puniſhe his chirche and choſen for theer ſinne. Whiche whither he do, he is glorified every waie, and dothe what he liketh beſt, bicauſe he knoweth what is beſt not onelie generallie for all, but eſpeciallie for everie one. Here is no news, but yor old frende *(e)* and mine is ſtubburn, he will not ſpeke of thoos pointes he is comanded, and of thoos he is charged to hold his peace of, he can not chuſe but ſpeke, beinge obedient to himſelf as a mule y^{t} carieth ye bit in her teth, and ſo lerned in his ſermone, y^{t} his frendes be aſhamed of him. A notable differens betwene autho-

ritee

(c) The alluſions to the interim in theſe letters are very numerous.

(d) The paſſage of Scripture which Sir John here alludes to, is, I believe, Amos viii. 11.—quoting from memory he might eaſily make ſuch a miſtake.

(e) The *old frende* here ſpoken of muſt have been Gardiner, Biſhop of Wincheſter, who was impriſoned about this time.

ritee and feare, in the which when one mai ſpeke boldlie and undangerd, everie thinge is wittie, in feare and unquietnes, a good wit fainteth, and a harebrained witt ſemeth ſtarke mad, for ye which ſingular diſobediens he hathe bene and is yet in the towre, a place y^t^ hath longed for him, ſins ye biſhop of romes abrogacon, or rather expulſion. In the whiche doinge ye fear of troble is taken awaie, the trueth of religion goeth forwarde, the waveringe me be confirmed, ye papiſtes be aſtonied, and everie thinge is wel mended. Of doutful Haddington, and ſkottiſhe matters, we wil write more in our next letters, the governemet of ye realme is deliverd bi parliamet there to ye frenche kinge, *(f)* y^e^ ſkeptre bi ye erle of argile, ye crowne bi ye erle of anguiſhe, y^e^ ſwerde bi therle of worth, y^e^ ſkottiſhe quene to be maried to ye dolphin of France, and embarked as it is ſuppoſed to take iornej into france. God ſend grace and y^t^ plentifullie, y^t^ even as haddington, was builded of great and neceſſarie conſideracons, even ſo bi his pleaſore we maie defende it from there violence whiche is yet likely inoughe to be kept. Fare ye mooſt hartelie wel, ye XVII of Julie 1548. 2. Ed. 6. from hampton courte. yor aſſured frendes.

Thomas Wrothe.
Joan Cheke.

POSTSCRIPT.

(f) This circumſtance is probably miſrepreſented through prejudice. I can find no account of it in Buchanan, and though the French intereſt was great it is very unlikely that ſuch a ſurrender ſhould be made. With reſpect to the ceremony of delivering

POSTCRIPT. After the ende of this letter cam there good newes of haddington, y^t ye fridaie afore ye date hereof or els ye thurſdaie, ye Scottes for lacke of p^ouiſion determined to go there waie whome ye frenſhmen did perſuade to tarie untill tueſdaie after, p^omiſinge in the mean ſeaſon to give thaſſault, thej have yet made no breche, but batterd a bulwarke, and approched ye ditche with trenches ſo y^t y^ei have ſomthinge underminded ye bulwarke but our men hath countermined them, ſo y^t there mine is to ſmall purpoſe. The frenſhmen entended alſo, to make a platforme on ye chirche bi, ſo to have beten ye wal within, y^t our men ſhold not have ben able to have defended y^t bulwarke for y^e ſhot of y^er ordinans, but our men hath ſo beten y^e ſtones about theer eares, y^t thej have diſmounted ij of theer peces, and theer platforme ſerveth them to no purpoſe. Our men within for the defence of ye bulwarke have made a counter trenche and a mounte within y^t, y^t dothe governe ye bulwarke, which the frenſhmen y^emſelves doth ſe to be hier then ye wal, ſo y^t this parte of haddington whiche thej entende to aſſaulte, is as ſtrong or ſtronger y^en ye reſidue. The forſaid thurſdaie our men made a ſalee out, and killed 30 of theer pioners, the ſame daie

delivering the ſcepter, &c. if ſuch a one took place, it muſt have been on ſome other occaſion. With reſpect to the three noblemen mentioned, Douglas Earl of Angus was one of the moſt zealous oppoſers of the French intereſt, and the Earl of Argyle who was chief juſtice in 1550 had not then diſtinguiſhed himſelf. *Worth* is a title which bears little or no reſemblance to any in Scotland at that time, nor can I conceive who was meant except it were the Earl of Morton, father-in-law of the Regent.

towarde night was ſent out of the towne, an hundred hack-butters *(g)*, 30 pikes, with 60 repers to get grene corne for theer horſes, theer was ſent out from ye frenſh, a nombre of horſeme, whereof Jamé dog was captain, and a nombre of ſotemen of the ringegraves bande *(h)*, whereof Monſ. Maree was captaine. O^r^ me notwithſtanding this force, brought in everie man his burden, and al ye men ſafe, and with ye helpe of o^r^ ordinance bent out of ye towne towarde that place, ſlew Monſ. Maree, hurte 60 mooſt parte dedlie, and left ij in the felde. The frenſhme accordinge to p^o^miſe made to y^em^ bi ye Scottes hath required ye deliverie of Edenboroughe caſtel unto the frenſh kinge *(i)*, for y^t^ ye navie of france laie theer at ye frenſhe kinges great charge, who ſhall not longe be unmett withal if it pleſe god, and had no ſafe place

(g) hackbutters. i. e. arquebuſiers or harquebutters, as appears from a paſſage in the intelligence from Scotland.

(h) Amongſt the troops ſent by the French king to Scotland were three thouſand Germans commanded by the Rhingrave. Buchan, lib. xv. ch. 54. The Rhingrave was a German prince who was driven from his own country by the Emperour Charles the 5th, whom he had oppoſed, and had entered into the French king's ſervice. He was much eſteemed as a ſoldier.

(i) This demand is not mentioned by Buchanan; but he gives an account of the French troops under Deſſé returning to Edinborough, and on being oppoſed by the Governor, killing him and many of the citizens; a circumſtance which proves that there was little agreement between the Scotch and their French allies. The Engliſh diſpatches repreſent almoſt every action and ſkirmiſh as favourable to the Engliſh troops, whilſt Buchanan repreſents things in a very different manner.

place to laie theer munición and treſor in: which ye Scottes wil in no wiſe agree unto, til Haddington be won, which ſhal be as good hope thinketh not this yere; How ye frenſhmen wil take ye fals p^o^miſinge Scottes when they have ones bene deceived inough it is not harde to ſaie. And for this time this is al, with our ſeconde farewel the daie and yere above-ſaide.

Joan. Cheke.

Thomas Wrothe.

(Mynute to the Lord Protecto^r^'s grace.)

It may pleaſe your grace to underſtaunde y^t^ th'emperor cam to this towne on teweſday laſt where he hathe begun to take the lyke order ffor the gov^r^naunce of the ſame y^t^ he uſed wth auſpurgh dyſcharging tholde counſell and placing ſuche other in theire ſteade as he thinkith meteſt wherin he hath ſo travailed as he hath alredy browght the ſame in forwardenes to be at a full poinct before monday next at thuttermoſt for as then he hath appoincted to dep^t^ hence towards ſphires and ffrom thence after a ſhort abode there ſtraught to flaunders as it is here commonly bruted. It is by lies out of Italy (as I am enformed by creadable men) written unto thempero^r^ that now of late certaine ſoldio^rs^ of the iſland of corſega to the nomb of X being by the duke Octavian

 appoincted

appoincted to ſleye don Fernando thempero[rs] lieutenant in Italy and being by one y[t] knewe of this conſpiracie dyſcovered were ij of them ſlaine (who with the reſt ſtode ſtoutelye at defence at the tyme of there apprehencon) and the reſt taken alyve who have confeſſed the hole circumſtaunce of this treaſon, theffect whereof is that the houſe of ferneſe aſwell the duke Octavian as the B of R had hired them to ſlay the ſayd don Fernando to what ende or uppon what occaſion they knewe not, this thing being conferred wth the ffrenche kings pnt repaire towards italye maketh men miſtruſt leaſt he be altogether unwitting thereof the rather for that aboght the tyme y[t] this man ſhold hav byn ſlayne he apointed to be in the confynes of piamount towards italye, which being ſo, what was ment ther by his nigh approche to mylaine and loſs of the gnall capitaune of the ſame doth eaſely declare, for which reſpect themper[r] it is ſayd ſendyth now into italie owt of this countrie ij[m] v[c] Spaniards fotemen and ij bands of horſemen, it is allſo reported by tres owt of italie that the B of R ffynding hym ſellf not thoroughly ſatisfied wth the ffrenche kings detracion in thaccomplyſhement of certayne poincts agreed upon in the league betwene them hath lately called to hym the ffrenche am. in Rome and declarid his grefe complayning y[t] he is not ſo well and frendly uſed as he ſuppoſed to have byn at the ffrenche kings hands it is of ſome coniectured hereby that the league betwene them is not altogether ſo ffirme as it was at the begning beleved which nevertheleſſe how it can agre wth the former newes I can by no means perceyve

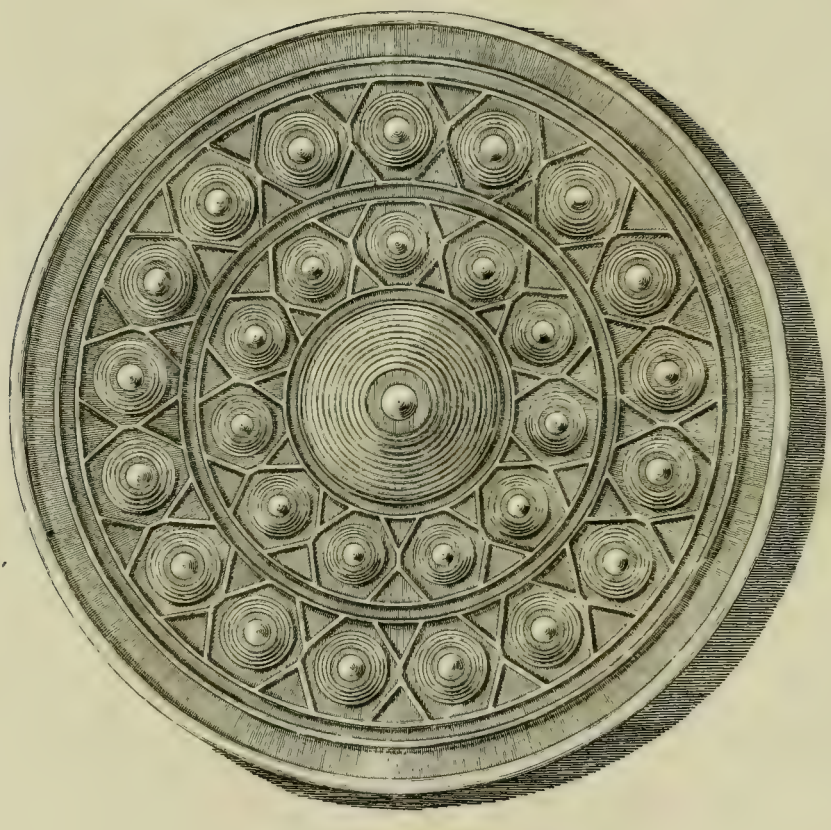
perceyve yet ffor y^{t} I have hard this thing ſo reported I have thought good amongſt the reſt to ſignifie it unto your grace. The ffrier y^{t} was thempero^{rs} confeſſo^{r} hath nowe willingly lefte y^{t} rome ſume doubt leſt he be becume a proteſtaunt, but the comon report wch ſemethe ye moſt certaine is y^{t} thoccaſion therof hath byn the ov^{r}much affection wherewth he ſeemed to favo^{r} the B of R cauſe which hath well appered in y^{t} he hath not a fewe tymes chargid thempero^{rs} conſciens wth the redeliverie of piazenſa, in his rome of confeſſo^{r}ſhip is enterid another ffrier who hath byn wth me ſundrie tymes and pretendyth a greate ffrendſhip towards me whoſe devocon towards the B of R ffor that I have p^{r}ceyved by him is ſo ſmall as he layeth the hole faulte of this p^{r}turbacon of the worlde (as he terms it) to hym, by this mans means under the pretenſe of this coloured ffrendſhip I hope to pike* out ſume what now and then.

ffrom Ulme, the XVIIJ day of auguſt a^{o} 1548.

[D 2]

N. B. In tranſcribing this letter, care has been taken to copy all the contractions, &c. but eraſures which are very frequent have not been noticed.

* It is hard to determine from the writing whether this word be *pike*, *peke* or *poke*, but the ſenſe ſeems to direct *pike* for *pick*.



ACCOUNT *of four* CIRCULAR PLATES *of* GOLD *found in* IRELAND. *By* RALPH OUSLEY, *M. R. I. A.*

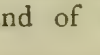
Read March 11, 1797

IN the month of October 1795, a peaſant near Enniſcorthy in the county of Wexford turned up with his plough four plates of ſolid gold, perfectly round, and of very neat wormanſhip; he ſold them to a Mr. Gurly of Enniſcorthy, ſilverſmith, who melted two of them down and ſent the other two for ſale to the Earl of Charlemont, Preſident of our Academy. The four were exactly alike, quite circular and four inches and three quarters in diameter, very thin, weighing about one ounce each, ornamented handſomely at one ſide and quite plain at the other, except a kind of cap or ſcrew for the purpoſe of being affixed to a handle. The annexed drawing, being exactly of the ſize and figure of one of them, will convey a better idea of theſe ancient articles than I can pretend to give of them—there being nothing like them in

Harris,

Harris, Smith, Vallancey, Gough or any other of our writers on antiquities, I thought it worth while to form ſome little account of theſe curious antiques, though I can by no means aſcertain their antiquity, or determine their uſe.

From the many articles of gold almoſt daily diſcovered in this kingdom it will not appear unreaſonable to ſuppoſe with our ancient hiſtorians, that Ireland once poſſeſſed mines of that precious metal, or elſe muſt have had a conſiderable traffick with ſome nation abounding in that commodity.

A few years ago Mr. Samuel Johns, a working ſilverſmith in Limerick, bought a very curious piece of thin gold of this ſhape  and of an exceeding fine quality, ſuppoſed to be a ſhield or breaſt plate: he got it from a labourer who found it in the pariſh of Feakle and county of Clare—it weighed upwards of twelve ounces; he gave three pounds eight ſhillings and three pence per ounce for it, and ſold it afterwards to Mr. Wm. D. Moore, Goldſmith in Dublin, for four pounds an ounce.

Another ſilverſmith or merchant of Limerick (Mr. Wm. Power) bought a very beautiful crown that weighed above one pound of pure gold, with a place for a precious ſtone in the center, moſt elegantly worked, and found near Shronehill, county Tipperary; it was unfortunately broke up for rings and toys, but has been ſeen by ſeveral of my acquaintances.

Another

ANOTHER ancient ornament (I ſuppoſe) I met with a few weeks ago; it was fifteen inches long, very thin and narrow, about a quarter of an inch broad, of fine gold and worth about a guinea, the ends have ſmall holes in them to admit a thread thro' and are of this ſhape (·————————·)
Such another was found a few years ſince near Ballinrobe, and was I believe in the poſſeſſion of the late Judge Hellen.

I AM perſuaded if curious gentlemen in our different provinces would apply themſelves attentively to the enquiry, and reward liberally the finders of gold and ſilver antiques, a number of very curious articles would ſoon be brought to light, to the amuſement of the literati, and the elucidation of our antiquities.

Limerick, January 25, 1797.